ATTACHMENT III
Point Thomson Project Environmental Report

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ExxonMobil
Development

November 19, 2009

U.S. Army Corps of Engineers
Regulatory Division
Post Office Box 6896
Elmendorf AFB, Alaska 99506-0898

Re: POA 2001-1082-M1, Beaufort Sea
Point Thomson Project – Environmental Report

Attention: Ms. Julie McKim, Hydrologist/Project Manager

Dear Ms. McKim:

Exxon Mobil Corporation (ExxonMobil) hereby submits the attached Point Thomson Project Environmental Report in support of the October 2009 draft Application for Department of the Army Permit (Sec. 404/10) and the Project Description for the Point Thomson Project (Project) previously submitted to your office. This submission is intended to facilitate agency review of the environmental effects of the Project including preparation of an Environmental Impact Statement (EIS), which the U.S. Army Corps of Engineers (USACE) has determined will be required for the Point Thomson Project.

This Environmental Report describes the key alternatives that were considered by ExxonMobil during the design process; the existing physical, biological and socioeconomic resources and environments in the Project area; the potential environmental effects of the Project; and the environmental mitigation measures to be incorporated into the Project design and construction and operational practices. In line with its corporate policies, ExxonMobil continues to evaluate means to enhance safety and environmental performance and mitigation measures for the Project.

Three electronic copies in PDF format of Chapters 1 through 5 of the Environmental Report are attached. Chapter 6 - Cumulative Effects, Chapter 7 - Bibliography, Chapter 8 List of Contributors, and a revised Table of Contents for the entire Environmental Report will be provided later under separate cover. The later submittal will be 3-hole punched to allow insertion into the enclosed document and will include revised CDs containing the entire Environmental Report.

ExxonMobil looks forward to working with the USACE, the federal and State agencies, the North Slope Borough, local communities, the USACE's third party EIS contactor and all interested parties to achieve a comprehensive, effective, and timely NEPA review and issuance of permits and approvals for the Project. We would be pleased to discuss any questions you have.

Sincerely,

R. Lee Bruce
Senior Project Manager
For and in Behalf of Exxon Mobil Corporation

RGD:eaa
Attachments

cc: Distribution List

w/o attachments
Commissioner Tom Irwin, ADNR
Corps Northern District Chief
Corps Regulatory Division Chief

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* Don Perrin will distribute to other State of Alaska agencies

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POINT THOMSON PROJECT

ENVIRONMENTAL REPORT

NOVEMBER 2009

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APPENDIX

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ACRONYMS AND ABBREVIATIONS

´	minutes
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
AAAQS	Alaska Ambient Air Quality Standards
AAC	Alaska Administrative Code
AADT	Annual Average Daily Traffic
ac	acre
ACIA	Arctic Climate Impact Assessment
ACMP	Alaska Coastal Management Program
ACP	Arctic Coastal Plain
acre-ft	acre-feet
ACS	Alaska Clean Seas
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ADOL	Alaska Department of Labor
ADOT	Alaska Department of Transportation
ADOT&PF	Alaska Department of Transportation and Public Facilities
AEWC	Alaska Eskimo Whaling Commission
AHRS	Alaska Heritage Resources Survey
AKNHP	Alaska Natural Heritage Program
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
ANS	Alaska North Slope
ANSER	Alaska North Slope Eastern Region
AO	Arctic Oscillations
AOGCC	Alaska Oil and Gas Conservation Commission
APDES	Alaska Pollutant Discharge Elimination System Permit
AS	Alaska Statute
ASG	American Shorebird Group
ASRC	Arctic Slope Regional Corporation
ASST	Arctic Small Tool Tradition
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AWC	Anadromous Waters Catalog
AWEC	Alaska Eskimo Whaling Commission
BACT	best available control technology
Bbbl	billion barrels
bbl	barrel

ACRONYMS AND ABBREVIATIONS (Continued)

bbls	barrels
BCB	Bering-Chukchi-Beaufort (seas)
BCF	bioconcentration factor
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMPs	best management practices
bpd	barrels per day
BPIFWG	Boreal Partners in Flight Working Group
BPXA	BP Exploration (Alaska)
BRAC	Base Realignment and Closure
CAA	Conflict Avoidance Agreement
CAH	Central Arctic Herd
CBS	Chukchi Bering Sea stock
CCP	Central Compressor Plant
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
CITES	Convention on International Trade in Endangered Species
cm/sec	centimeter per second
CNS	central nervous system
CO	carbon monoxide
CO_2	carbon dioxide
CPF	Central Processing Facility
CRA	Corrosion resistant alloy
CRU	Climate Research Unit
CS	State of Alaska Contaminated Sites database
cy	cubic yards
dB	decibel
dBA	A-weighted decibel
DCCED	Alaska Department of Commerce, Community, and Economic Development
DEW	Distant Early Warning
DH	Dockhead (to be followed by a specific number)
DLP	defense of life and property
DO	dissolved oxygen
DOC	dissolved organic carbon
DOI	Department of Interior
DR&R	dismantle, remove, and restore

ACRONYMS AND ABBREVIATIONS (Continued)

E&P	exploration and production
EA	Environmental Assessment
EC	Effective Concentration (followed by a subscripted number indicating percent)
EFH	essential fish habitat
EIS	Environmental Impact Statement
EMT	Emergency Medical Technician
EOR	enhanced oil recovery
EP	export pipeline
EPA	U.S. Environmental Protection Agency
EQC	equilibrium compartment
ER	Environmental Report
ESA	Endangered Species Act
ExxonMobil	Exxon Mobil Corporation
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act
FERC	Federal Energy Regulatory Commission
FOM	Facilities Operation Manual
FR	Federal Register
FL	flare systems
FLIR	forward-looking infarred
FOSC	Federal On-Scene Commander
fps	feet per second
FRP	Facility Response Plan
FSB	Federal Subsistence Board
ft	foot
FHWA	Federal Highway Administration
g	gram(s)
g/m^2	grams per square meter
GC	Gathering Center (followed by an identifying number)
GHCN	Global Historical Climatology Network
GHG	greenhouse gas
GIS	Geographic Information Systems
GMU	Game Management Unit
ha	hectare(s)
HAZWOPER	Hazardous Waste Operations and Emergency Response
HC	hydrocarbon
HP	high-pressure
HUD	U.S. Department of Housing and Urban Development
Hz	Hertz
ICAS	Inupiat Community of the Arctic Slope

ACRONYMS AND ABBREVIATIONS (Continued)

ID	identification
IHLC	Inupiat History, Language, and Culture Division of the North Slope Borough
IMT	incident management team
in	inch
IPCC	Intergovernmental Panel of Climate Change
ITR	incidental take regulations
IWC	International Whaling Commission
JIP	joint industry project
JPO	Joint Pipeline Office
kHz	kilohertz
kJ	kilojoules
KIC	Kaktovik Inupiat Corporation
km/hr	kilometers per hour
km^2	square kilometers
LC_{50}	lethal concentration of 50 percent
LD_{50}	lethal dose of 50 percent
L_{dn}	Day-Night Average Noise Level(s)
LEK	local environmental knowledge
LEL	lower explosive limit
L_{eq}	Equivalent Noise Level(s)
L_{max}	Maximum Sound Pressure Levels
LMR	Land Management Regulations
LOA	Letter of Authorization
LORS	laws, ordinances, regulations, and standards
LP	low-pressure
LPAMP	Liberty Project Air Monitoring Program
LRDD	Long Reach Directional Drilling
M	magnitude
m^3/sec	cubic meters per second
MG	millions of gallons
mg/m^3	milligrams per cubic meter
mg/L	milligrams per liter
MHW	mean high water
mL	milliliters
MLLW	mean lower low water
mm	millimeter
MMbbl	million barrels
MMPA	Marine Mammals Protection Act
MMS	U.S. Department of Interior, Minerals Management Service
mmscfd	million standard cubic feet per day

ACRONYMS AND ABBREVIATIONS (Continued)

$MMTCO_2e$	million metric tons CO_2-equivalent
MSL	mean sea level
M_W	moment magnitude
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NAD83	North American Datum 1983
NAO	North Atlantic Oscillations
NAWCP	North American Water Bird Conservation Plan
NBS	Northern Beaufort Sea
NCDC	National Climatic Data Center
ND	not dated
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NH_4	ammonium
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPR-A	National Petroleum Reserve - Alaska
NRC	National Research Council
NSB	North Slope Borough
NSIDC	National Snow and Ice Data Center
NTIS	National Technical Information Service
NTU	nephelometric turbidity unit
NWI	National Wetland Inventory
O_3	ozone
OCS	Outer Continental Shelf
OCSEAP	Outer Continental Shelf Environmental Assessment Program
ODPCP	Oil Discharge Prevention and Contingency Plan
OHA	Alaska Office of History and Archeology
OIMS	ExxonMobil's Operations Integrity Management System
OSHA	Occupational Safety and Health Administration
PAH	polyaromatic hydrocarbon
PBAAMP	Prudhoe Bay Ambient Air Monitoring Program
PBR	potential biological removal
PDEIS	Preliminary Draft Environmental Impact Statement
PDO	Pacific Decadal Oscillation
PF	power facility
PGA	peak ground acceleration

ACRONYMS AND ABBREVIATIONS (Continued)

PH	Porcupine Herd
PHMSA	Pipeline Hazardous Materials Safety Act
PIF	Partners in Flight
PL	Public Law
PM_{10}	particles of 10 micrometers (microns) or less
$PM_{2.5}$	particles less than 2.5 micrometers (microns) in aerodynamic diameter
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
precip	precipitation
Project	Proposed Point Thomson Project
Project Description	Proposed Point Thomson Project Description
PSD	prevention of significant deterioration
PTU	Point Thomson Unit
RCG	Regulatory Control Group
RCRA	Resource Conservation and Recovery Act Compensation
RD	reservoir development
Refuge	Arctic National Wildlife Refuge
RLF	revolving loan fund
RMS	root-mean-square
RO	road development options
ROI	region of influence
ROW	right of way
SBS	Southern Beaufort Sea
SD	standard deviation
SPMT	Self Propelled Modular Transporters
SO_2	sulfur dioxide
SPCC	Spill Prevention Control and Countermeasures
SPCO	State Pipeline Coordinator's Office
SPL	sound pressure level
sq. mi.	square mile
SRRS	Short-range Radar Station
state	State of Alaska
SVOC	semi-volatile organic compound
TAPS	Trans Alaska Pipeline System
T	transportation options
TDS	total dissolved solids
TH	Teshekpuk Herd
TLK	Traditional and Local Knowledge
TLUI	Traditional Land Use Inventory
TSS	total suspended solids

ACRONYMS AND ABBREVIATIONS (Continued)

TWA	time-weighted average
U.S.	United States
UEL	upper explosive limit
UIC	underwater injection control
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USC	United States Code
USCB	United States Census Bureau
USCG	United States Coast Guard
USDOI-BLM	United States Department of Interior - Bureau of Land Management
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USGS-BRD	United States Geological Survey-Biological Resources Discipline
USSCP	United States Shorebird Conservation Plan
VHF	very high frequency
VIA	Visual Impact Assessment
VMC	Visual Management Classes
VOCs	volatile organic compounds
VRA	Visual Resources Assessment
VSMs	vertical support members
VSR	volumetric spill rate
WAH	Western Arctic Herd
WCC	Woodward Clyde Consultants
WGS84	World Geodetic System 1984
WRCC	Western Regional Climate Center
YOY	young-of-the-year
$\mu g/m^3$	micrograms per cubic meter
μPa	micropascals
μS/cm	microsiemens per centimeter
μS/m	microsiemens per meter

1.0 INTRODUCTION

THE POINT THOMSON PROJECT

The proposed Point Thomson Project (hereinafter the Project) is described in the Point Thomson Project Description (Project Description) (Exxon Mobil Corporation [ExxonMobil] 2009a). A summary of the Project Description is set forth in Section 1.5. The Project Description details Project components and activities, including safety, security, health, and environmental planning; reservoir description; drilling plans and support facilities such as gravel pads, pipelines, roads, and housing; construction and operations plans; spill prevention and response planning; and waste management.

1.1 PURPOSE OF THE ENVIRONMENTAL REPORT

The purpose of this Environmental Report (ER) is to assist permitting agencies and other interested parties in understanding the Project and assessing its potential benefits and effects. The ER is intended to facilitate the National Environmental Policy Act (NEPA) review process and processing of associated federal, state, and local permits. It is also intended to provide all interested parties with information to assist their participation in formal permit and NEPA review opportunities.

The ER addresses current and evolving circumstances in the affected environment of the North Slope and Project area, including both natural effects and development activities on the North Slope. The ER is based upon information in the Project Description and draft Department of the Army 404 Permit Application (ExxonMobil 2009b). While building upon earlier environmental studies at Point Thomson, it incorporates current sources about the physical, biological, and human environment of the North Slope of Alaska and the Project area.

In all of these respects, the purpose of the ER is also to provide a thorough consideration of environmental values of the Project, including traditional and contemporary knowledge of North Slope residents, potential alternatives, and potential impact mitigation measures.

The ER also reflects ExxonMobil's fundamental commitment to environmental and safety excellence. ExxonMobil's senior management has reinforced this commitment to environmental performance across all business lines and at all levels with a corporate initiative called **Protect Tomorrow. Today.** Through this directive it is ExxonMobil's goal "to achieve superior environmental performance and be recognized as an industry leader who operates responsibly everywhere we do business, and who, in doing so, will **Protect Tomorrow. Today**". Further, it is our vision that the Point Thomson Project will be viewed as the "Standard for Arctic Environmental Excellence."

1.2 SCOPE OF ENVIRONMENTAL REPORT

The ER will address the following topics:

- Project description, purpose, and need;
- Analysis of Project components and alternatives for development;
- Description of the affected environment associated with development of the Project;

- Analysis of potential environmental consequences, both beneficial and adverse, associated with development of the Project;
- Mitigation measures that have been incorporated into the design, construction, and operation of the Project to avoid or reduce Project effects;
- Analysis of the incremental contribution of the Project to cumulative effects of resource development and other activities on the North Slope of Alaska;
- References used in preparing this ER; and
- List of individuals who contributed to the preparation of this ER.

Major Project components and activities that constitute the proposed action are described in the Project Description. This ER is designed to provide necessary information to support agency decision-making for regulatory actions. Alternative Project components of the proposed action are analyzed in Chapter 2 (Analysis of Development Components) of this ER as a basis for alternatives evaluation required by the NEPA regulations (40 Code of Federal Regulations [CFR] 1502.14), regulations of the U.S. Army Corps of Engineers (USACE) (33 CFR 325-Appendix B), and U.S. Environmental Protection Agency (EPA) 404(b)(1) Guidelines (40 CFR 230). Chapter 3 (Affected Environment) and Chapter 4 (Environmental Consequences) are intended to provide information to assist in satisfying NEPA requirements set forth in 33 CFR 230.34. Mitigation measures incorporated into the Project design are described in Chapter 5 (Mitigation Measures), which is intended to establish the basis for regulatory review for conformance with the requirements of Section 404(b)(1) guidelines and for other permit decision-making. Chapter 6 (Cumulative Effects) considers the cumulative effects of the Project in combination with external actions within the Project area. Chapter 7 is the Bibliography and Chapter 8 presents the List of Contributors.

1.3 PROJECT PLANNING AND STAKEHOLDER INVOLVEMENT

ExxonMobil understands that careful project planning and community engagement are key to obtaining support for development in the Project area, and will ultimately result in a balanced, acceptable project. ExxonMobil recognizes that it is important to engage, inform, listen to, and address concerns raised by federal and state agencies, the North Slope Borough (NSB), local communities (such as Kaktovik, Nuiqsut, and Anaktuvuk Pass), Alaska Native corporations and tribal governments, and the business community to successfully progress the Project.

ExxonMobil's plans in this regard include:

- Actively participating in the NEPA process as requested by the USACE;
- Conducting regular open discussions with applicable federal and state agencies;
- Working closely with the NSB Planning Department and affected communities on the North Slope; and
- Providing regulators and other interested parties timely information to facilitate evaluation of project issues.

1.4 PROJECT PURPOSE AND NEED

The Project will initiate development of the Thomson Sand reservoir and initiate commercial hydrocarbon production by the end of 2014. The Project will deliver condensate to the Trans Alaska Pipeline System (TAPS) Pump Station No. 1 at Prudhoe Bay for shipment to market. Initial average production of condensate is expected to be approximately 10,000 barrels per day (bpd). The Project will evaluate other potential hydrocarbon resources in the Point Thomson area, such as the Brookian Group sandstones, and the design will include the capability to produce up to 10,000 bpd of oil.

Drilling of two wells is underway from the existing Central Pad. The Alaska Department of Natural Resources (ADNR) has authorized the current drilling program as in the public interest. This drilling program has been found to be consistent with applicable standards of the Alaska Coastal Management Program (ACMP) and necessary permits and authorizations have been received.

ExxonMobil has committed to the production of condensate and, if viable, oil from the Thomson Sand. The ADNR has accepted this commitment and has authorized production by the end of 2014. The Project will achieve this purpose.

Production of condensate and oil resources at Point Thomson serves other public purposes and needs. Development of this resource will help the United States meet domestic energy demand and reduce dependence on foreign sources of oil. Production at Point Thomson will help offset declining production from Alaska's North Slope reservoirs, and will help maintain the efficiency of TAPS.

The Project will provide economic benefits to the state, NSB, and local communities through the creation of new jobs and tax revenues. The Project will provide an important source of employment for Alaska businesses, workers, and local residents. This will include both temporary jobs during drilling, engineering, procurement, and construction, and long-term jobs supporting permanent operations. The Project will be a source of new revenue for the State of Alaska and the NSB, helping to offset declining revenue from existing hydrocarbon production and facilities.

ExxonMobil believes the Project represents the best plan for field development, considering geological, resource, commercial, and legal uncertainties. A principal goal of the Project is to establish a design footprint which will facilitate full development of the reservoir and delineation of the hydrocarbon resources of Point Thomson with the least environmental impact. The Project's design and flexibility accommodates foreseeable options for production by 2014 and beyond.

The Project features a three-pad configuration, the optimum development design for resource recovery, delineation, and conservation, and encompasses the smallest footprint necessary for these purposes. The configuration of the Project is designed to delineate and produce reservoir resources by using long-reach directional drilling techniques from onshore pads.

Development of the Point Thomson field resources beyond 2014 is dependent upon many factors that cannot be determined at present. The Project will provide a flexible footprint for the future.

Point Thomson is the largest discovered, undeveloped natural gas field in Alaska. No pipeline exists to bring Alaska North Slope natural gas to market, and there is substantial uncertainty about whether or when such a pipeline may be constructed. Nevertheless, should such a pipeline be built, natural gas from Point Thomson would be an important energy source for the United States and Alaska. Gas production and delivery into a pipeline is not part of the Project, but is addressed in the cumulative effects analysis of the ER.

1.5 PROJECT SUMMARY

The Point Thomson field is located along the coast of the Beaufort Sea, on the eastern North Slope of Alaska, approximately 22 miles east of the Badami Development and west of the Staines River boundary of the Arctic National Wildlife Refuge (hereinafter the Refuge) (Figures 1-1 through 1-3). The Thomson Sand is a high-pressure gas reservoir with a thin oil rim that underlies state lands onshore and state waters offshore. Other hydrocarbon accumulations exist and these will be evaluated by the Project to the extent practical.

Drilling and production facilities will be consolidated into three onshore gravel pads connected via gathering lines and roads. Offshore portions of the reservoir will be developed using long reach directional drilling techniques. Consolidating the facilities and using onshore pads reduces the overall environmental footprint and impacts of the Project.

ExxonMobil, working interest owner and operator, is proposing to produce gas from the reservoir, recover liquid condensate from natural gas and re-inject the residual gas back into the reservoir; thus, conserving it for future use. This gas cycling process is further described in the Project Description.

A minimum of five wells will be drilled from three pads: a Central Pad, and East and West pads located to access the eastern and western extent of the reservoir. Necessary authorizations to drill an injector well and a producer well pair at the Central Pad have been received, and drilling is ongoing.

Wells drilled from the East and West pads will be designed to penetrate and evaluate the oil rim to determine if production from the oil rim is viable. If the oil rim is determined to be viable, gathering lines will connect the East and West pads to the Central Pad, and will deliver the produced hydrocarbon stream to the Central Processing Facility (CPF). The Brookian formation will also be evaluated when present.

At the CPF, the three-phase stream (gas, water, and hydrocarbon liquids) from the wells will be separated, and liquid condensate will be recovered. Condensate is the hydrocarbon liquid that condenses from the produced natural gas as pressure and temperature fall below original reservoir conditions during production and surface handling in processing facilities. The separated condensate will be dehydrated and stabilized at the CPF to meet oil pipeline specifications.

The CPF is designed to process approximately 200 million standard cubic feet per day (mmscfd) of natural gas to recover approximately 10,000 bpd of condensate. The facility design includes the capability to produce up to 10,000 bpd of oil, if production from the oil rim is viable.

After separation at the CPF, produced gas will be conserved by being compressed and re-injected into the reservoir. Produced natural gas will be used as the primary fuel source for the facility, with diesel fuel used for back-up and in case of an emergency. Produced water will be injected into a Class 1 disposal well.

The hydrocarbon liquids (condensate and oil) will be shipped through an approximately 22-mile long, elevated export (sales) pipeline that will be constructed from Point Thomson to Badami (Figure 1-4). This new pipeline will tie into the existing Badami common carrier pipeline, which connects with the existing common carrier oil sales pipeline system to TAPS Pump Station No. 1.

The Central Pad will also include the infrastructure to support remote operations and drilling including: construction and operations camps; offices, warehouses, and shops; electric power generating and distribution facilities; diesel fuel, water, and chemical storage; treatment systems for drinking water and wastewater; a grind and inject module; waste management facilities; and communications facilities.

A gravel airstrip will be constructed for all-season transportation and emergency evacuations. To facilitate offloading of sealift modules, a bulkhead and dolphins will be installed, and minor dredging will be conducted. An in-field gravel road will be constructed, but a gravel road between Point Thomson and other Alaska North Slope infrastructure is not planned. Winter ice roads will be used for construction and other activities and in support of operations, as needed. A gravel mine will be developed to support construction. The mined pit will be converted to a water reservoir to provide a freshwater source for operations.

Table 1-1 provides a summary of the civil works associated with the Project.

TABLE 1-1: SUMMARY OF CIVIL WORKS

Structures	Dimensions[1] (feet) (length x width x minimum height)	Approximate Volume (cubic yards)	Affected Acreage
Drill Pad Roads[2]	11.4 miles x 32 x 5	726,400	88.8
Access Roads[3]	4,963 x 24 x 5	51,900	7.0
Central Pad	1,730 x 1082 x 5	673,200[4]	36.1[4]
Emergency Response Boat Launch – above MHW	Included in Central Pad	Included in Central Pad	Included in Central Pad
Emergency Response Boat Launch – below MHW	150 x 16 x 0.6	84	0.1
Emergency Response Boat Launch: Gangway Pilings	N/A	N/A	<0.1
Barge Offloading Bulkheads: Access Approach and High and Low Bulkheads[5]	N/A	17,800	1.2
Barge Offloading Bulkheads: Mooring Dolphins[6]	N/A	N/A	<0.1
Barge Offloading Bulkheads:	150 x 400	Up to 1,500	1.4

Structures	Dimensions[1] (feet) (length x width x minimum height)	Approximate Volume (cubic yards)	Affected Acreage
Dredging and Screeding			
Barge Offloading Bulkheads: Dredging Spoils[7]	1,015 x 20 x 2	1,500	0.9
East Pad	900 x 730 x 5	207,500[8]	14.2[8]
West Pad	800 x 800 x 5	280,000	18.2
C-1 Pad	230 x 520 x 5	13,000[9]	0.0[9]
Water Source Access Pad	120 x 100 x 5	4,600	0.6
Airstrip[10]	5,600 x 200 x 5	474,700	44.1
Gravel Storage Pad[11]	530 x 530 x as required	200,000	10.7
Gravel Mine Site	1,880 x 1,250 x 48	3,379,100[12]	59.3
VSMs	N/A	N/A	<0.1

Notes:
[1] Crown and height dimensions detail area at top of fill and height of fill. Side slopes are used to calculate affected acreage.
[2] Includes the gravel quantities for roads to the Central Pad, East Pad, West Pad, gravel mine, and stream diversion roads.
[3] Includes the gravel quantities for access roads to the airstrip, NavAid Pad, C-1 Pad, and Water Source Pad.
[4] Numbers for new gravel fill and affected acreage are presented here. Existing gravel fill at Central Pad encompass 12.4 acres; the newly placed 673,200 cubic yards (cy) of gravel fill will encompass 36.1 new acres for a total of 48.5 acres filled above mean high water (MHW).
[5] Fill for access approach and bulkheads is above MHW.
[6] Mooring dolphins will be placed below MHW.
[7] Dredging spoils will be placed above MHW.
[8] Numbers for new gravel fill and affected acreage are presented here. Existing gravel fill at East Pad encompasses 3.5 acres; the newly placed 207,500 cy of gravel fill will encompass 14.2 new acres for a total of 17.7 acres filled.
[9] Numbers for new gravel fill and affected acreage are presented here. Existing gravel fill at Alaska State C-1 Exploration Well Pad encompass 4.4 acres, the newly placed 13,000 cy of gravel fill will encompass no new acres.
[10] Airstrip estimated footprint includes helipad and navigational aid (NavAid) pads.
[11] Gravel stockpile dimensions are for base of the stockpile; height and side slopes as required.
[12] Includes gravel, inorganic overburden, and organic overburden.
< = less than
MHW = mean high water
N/A = not applicable

1.6 PROJECT SCHEDULE

The estimated timeframes for major elements of the Project are shown in Table 1-2. ExxonMobil and other owners are proceeding with plans to have the Project in production by the end of 2014.

TABLE 1-2: POINT THOMSON PROJECT SCHEDULE

Project Element	Estimated Time Frame	Description
Conceptual Engineering	September 2008 – June 2009	Initial engineering design.
Mobilize Drilling Rig	Winter 2008 – 2009	The drilling rig was mobilized from Prudhoe Bay to Point Thomson during the winter of 2008-2009.
Drilling	Through 2010 for PTU-15 and PTU-16 (additional drilling will occur as required).	Drilling is being conducted with one rig at the present time.
Environmental Studies	Summer 2010 (if necessary).	Environmental studies will be planned and initiated in accordance with discussions with resource agency personnel.
Front End Engineering Design (FEED)	2009 – 2010	Preliminary engineering, optimization, technical definition, and execution planning.
Construction- and Operations-Related Permits	July 2009 – December 2011	All applicable U.S. federal, state, and local permits secured to construct and operate production facilities and the export pipeline.
Detail Engineering	July 2010 – June 2012	Detailed engineering, procurement, and execution planning to support fabrication and construction.
Engineering Support	June 2010 – start-up	Follow-on engineering support for fabrication, installation, hookup, and commissioning.
Fabrication of Processing Modules and Other Equipment	2011 – 2013	Off-site fabrication of modular processing equipment, utilities, and other equipment.
Gravel Construction	December 2011 – Late April/Early May 2012	Gravel construction is expected to commence late in 2011 utilizing equipment mobilized over ice roads. Most gravel work at the Project site is expected to be completed within one winter season with gravel being obtained from a new local mine site.
Support Infrastructure Construction	Winter 2011 – Winter 2013	Construction of infrastructure such as airstrip, infield roads, power generation, storage tanks, and temporary camps.
Module Transportation	Summer 2013	Modules for the Central Pad will be brought to Point Thomson by sealift and offloaded at the Barge Offloading Facility.
Module Installation and Commissioning	Summer 2013 – Summer 2014	Place and install the modules at Point Thomson and begin testing for commissioning.
Pipeline Construction	January 2013 – April 2013	Pipeline construction is expected to commence in winter 2013 and be completed by April 2013.
Production	4th Quarter 2014	Production from Point Thomson is expected to commence by the end of 2014.

1.7 PERMITS AND AUTHORIZATIONS

Major permits, authorizations, and regulatory reviews required for construction and operation of the Project are listed in Table 1-3. This list is not comprehensive, but represents the broad range of regulatory authorizations needed for Project development. Permit applications will address information needs required by regulation and identified by agencies during the pre-application process.

TABLE 1-3: KEY REGULATORY ACTIONS

Regulatory Action	Regulatory Agency	Project Activity
Federal		
NEPA Review/Environmental Impact Statement	USACE; Lead NEPA Agency	Review of environmental impacts of entire Project, including construction and operations
Department of the Army Section 404/10 Permit	USACE	Placement of fill onto wetlands and structures in navigable waters
NPDES/APDES General Permit	EPA/ADEC	Wastewater and Stormwater discharges
LOAs for Incidental Take of marine mammals (polar bear and walrus)	USFWS, Marine Mammal Section	Annual LOAs for construction and operations
Section 7 Endangered Species Act Consultation	USFWS	Consultation for spectacled eider, Steller's eider, and polar bears
Essential Fish Habitat Determination	NMFS	Essential Fish Habitat
Section 7 Endangered Species Act Consultation	NMFS	Consultation for bowhead whales, for operations and construction
Spill Prevention, Control, and Countermeasure Plan	EPA	For construction, drilling, and operations
Facility Response Plans	EPA, USDOT	For construction, drilling, and operations
State		
Plan of Development and Operation	ADNR, Division of Oil and Gas	For project development
Alaska Coastal Management Program Review	ADNR, Division of Coastal and Ocean Management	Coastal zone consistency analysis for federal and state permits
Air Quality Control (PSD) for Construction	ADEC	Before construction can commence
Title V Air Permit for Operations	ADEC	Operations air emissions
Drilling waste storage and solid waste disposal facility	ADEC	Waste management
Pipeline Right-of-Way Lease	ADNR, State Pipeline Coordinators Office	Pipeline construction, operations, and abandonment on state land
Oil Discharge Prevention and Contingency Plan	ADEC	Drilling and operations
Land Use Permit	ADNR, DMLW	Miscellaneous land use (e.g., ice roads)
Temporary Water Use Permit	ADNR, DMLW	Water use for ice roads, drilling, domestic, and construction activities
Material Sales Contract	ADNR, DMLW	Gravel mining
Title 16 Fish Habitat Permit	Alaska Department of Fish and Game	Mine site development, ice road water withdrawal, and stream crossings
Cultural Resources Management Plan	ADNR, State Historic Preservation Office	Clearance prior to commencing construction

Regulatory Action	Regulatory Agency	Project Activity
Local		
Master Plan, Re-zoning and Development Permits	North Slope Borough	For construction and operations within the North Slope Borough

Notes:
ADEC = Alaska Department of Environmental Conservation
ADNR = Alaska Department of Natural Resources
APDES = Alaska Pollutant Discharge Elimination System
DMLW = Division of Mining, Land, and Water
EPA = U.S. Environmental Protection Agency
LOA = Letter of Authorization
NEPA = National Environmental Policy Act
NMFS = National Marine Fisheries Service
NPDES = National Pollutant Discharge Elimination System
PSD = Prevention of Significant Deterioration
USACE = U.S. Army Corps of Engineers
USDOT = U.S. Department of Transportation
USFWS = U.S. Fish and Wildlife Service

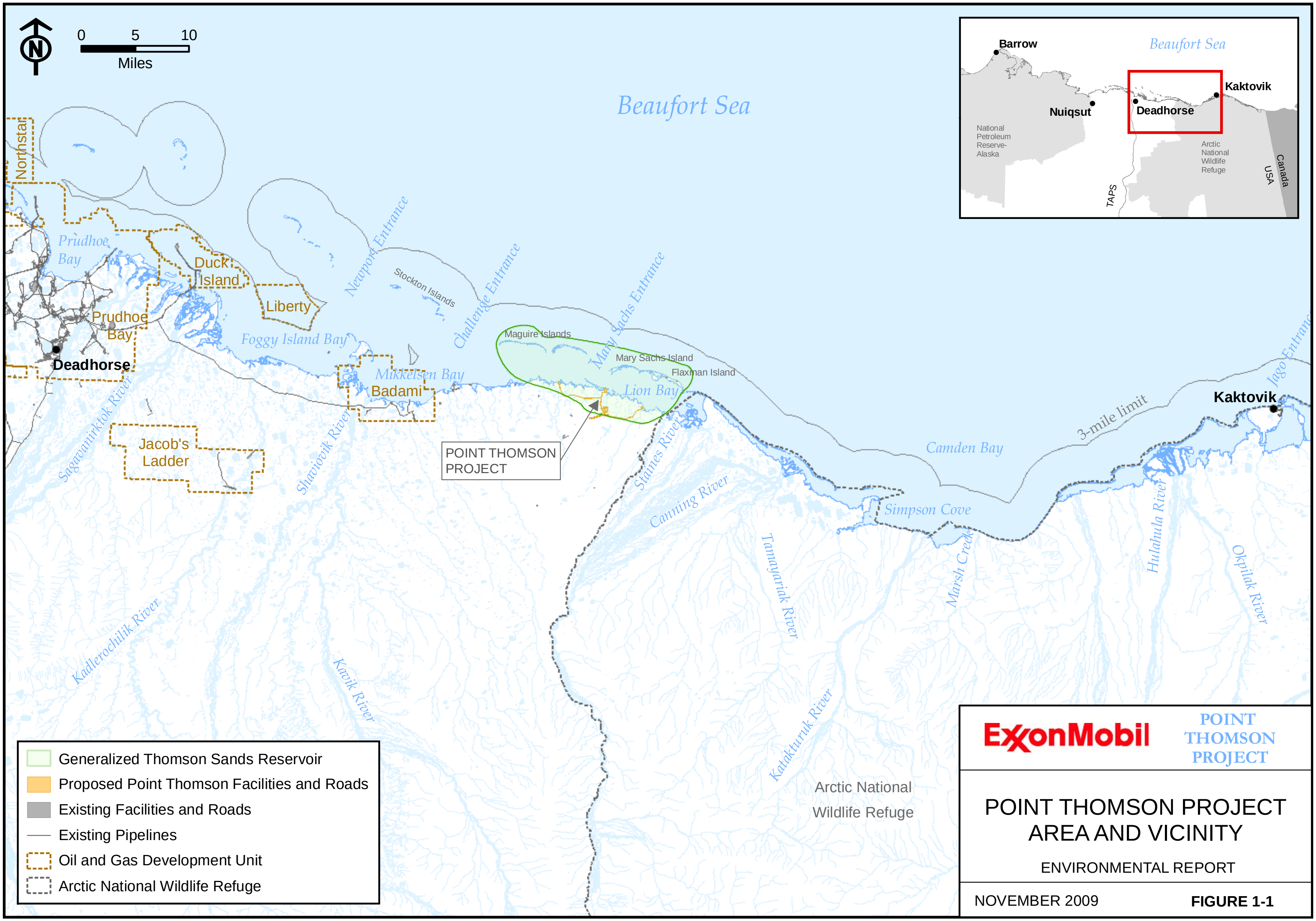
1.8 CURRENT DRILLING PROGRAM

ExxonMobil received authorizations for drilling the PTU-15 and PTU-16 wells on the Central Pad. These activities are described in the Plan of Operations dated 10 February 2009. The drilling program and other activities described in the Plan of Operations encompass the following:

- Drill two wells that can be used for production operations. One of the wells will be designed to be a producing well (PTU-16) and the other an injection well (PTU-15), which can also be used as a producing well. The PTU-15 and PTU-16 wells will provide additional information on the hydrocarbon resources of the Point Thomson area.
- Obtain reservoir quality and performance information for field development and potential facility expansion planning.
- Further delineate the hydrocarbon resources of the Point Thomson area, including the Thomson Sand, the Brookian, and Pre-Mississippian, where practicable. Testing of wells will be conducted.
- Bring the wells on production by year-end 2014 through construction of production facilities, pipelines, and other production infrastructure.

The Central Pad was chosen as the site for these wells because of its location from a reservoir and facility development perspective. It also encompasses the existing gravel pad used for the PTU-3 well, which reduces the new gravel footprint required for the Central Pad.

Chapter 1 – Introduction
List of Figures



POINT THOMSON PROJECT AREA AND VICINITY

ENVIRONMENTAL REPORT

NOVEMBER 2009 **FIGURE 1-1**

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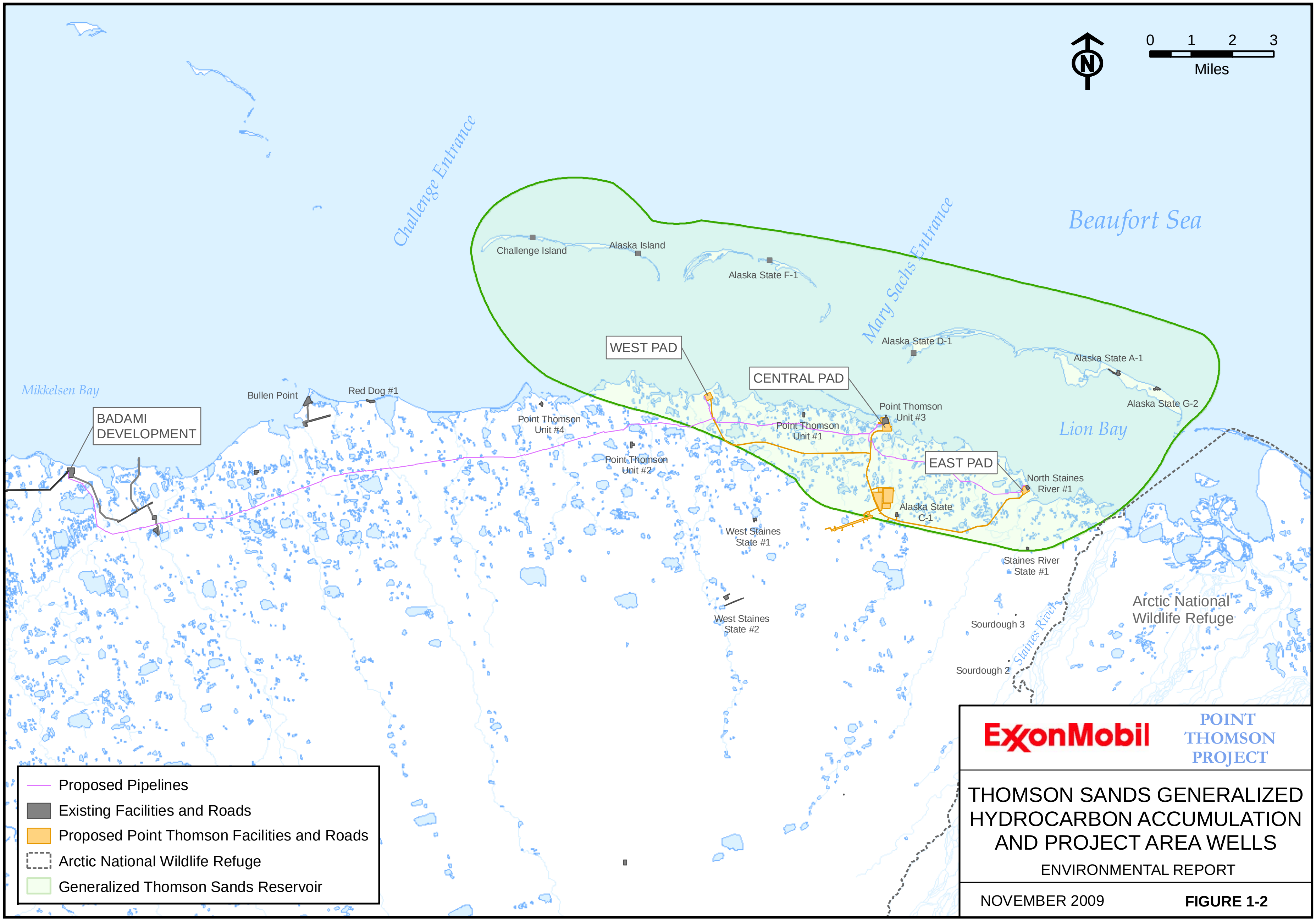
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Lion Bay
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Challenge Island
Alaska Island
Alaska State F-1
Alaska State D-1
Alaska State A-1
Alaska State G-2
WEST PAD
CENTRAL PAD
EAST PAD
BADAMI DEVELOPMENT
Bullen Point
Red Dog #1
Point Thomson Unit #4
Point Thomson Unit #3
Point Thomson Unit #1
Point Thomson Unit #2
North Staines River #1
Alaska State C-1
West Staines State #1
West Staines State #2
Staines River State #1
Staines River
Sourdough 3
Sourdough 2
Arctic National Wildlife Refuge
Proposed Pipelines
Existing Facilities and Roads
Proposed Point Thomson Facilities and Roads
Arctic National Wildlife Refuge
Generalized Thomson Sands Reservoir
ExxonMobil
POINT THOMSON PROJECT
THOMSON SANDS GENERALIZED HYDROCARBON ACCUMULATION AND PROJECT AREA WELLS
ENVIRONMENTAL REPORT
NOVEMBER 2009
FIGURE 1-2
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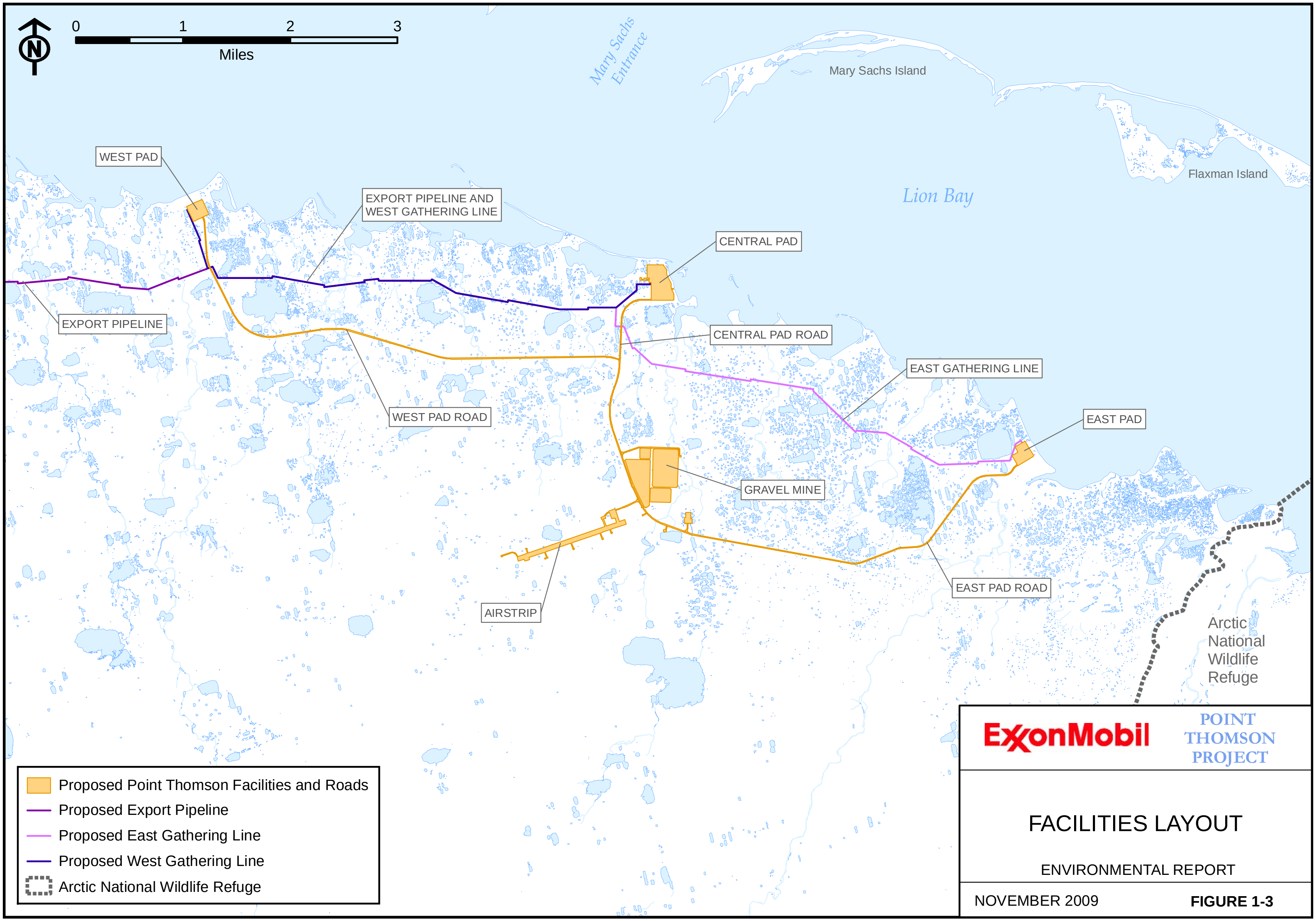
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EXPORT PIPELINE AND
WEST GATHERING LINE
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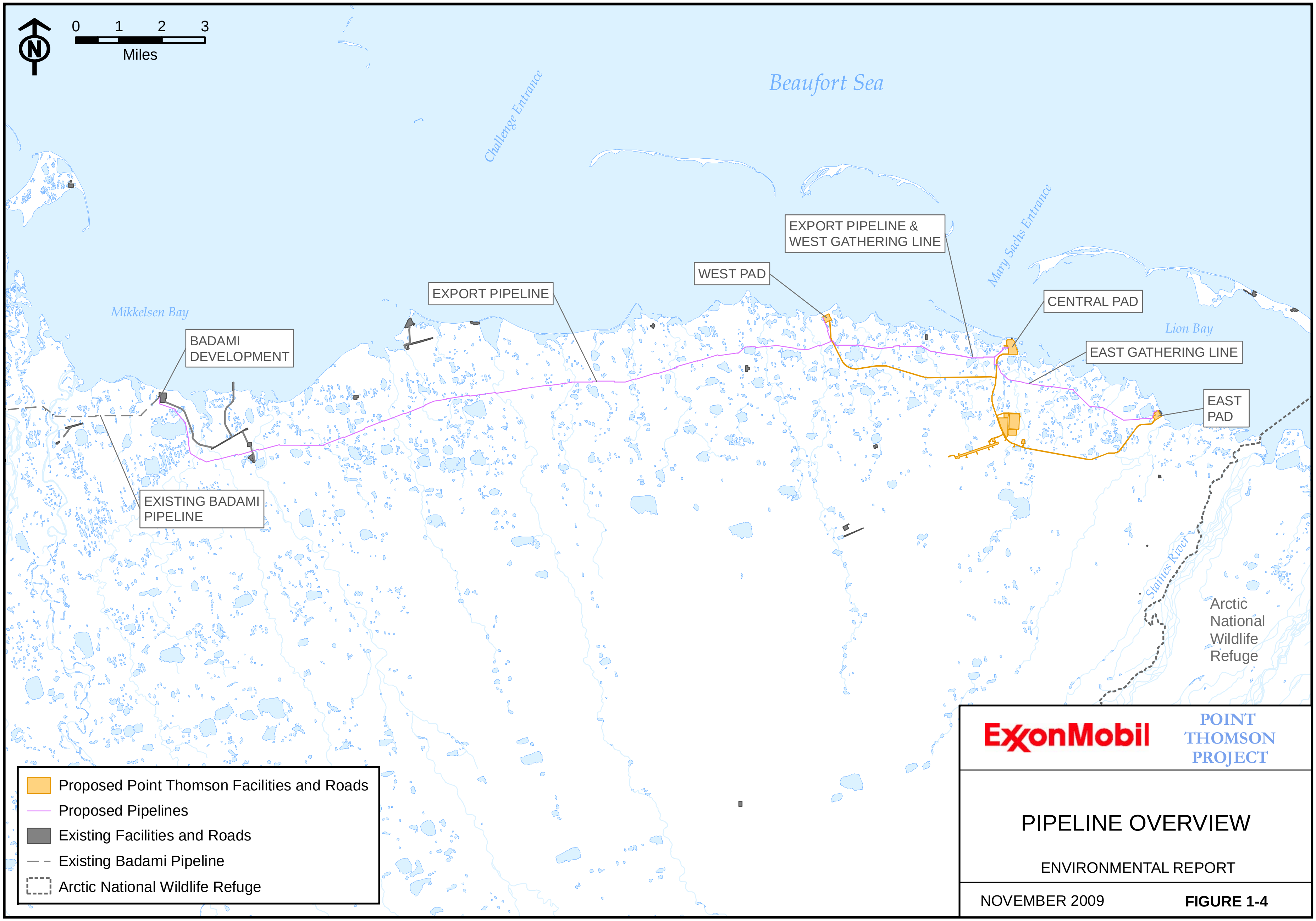
EXPORT PIPELINE
CENTRAL PAD ROAD
EAST GATHERING LINE
WEST PAD ROAD
EAST PAD
GRAVEL MINE
EAST PAD ROAD
AIRSTRIP
Arctic
National
Wildlife
Refuge
Proposed Point Thomson Facilities and Roads
Proposed Export Pipeline
Proposed East Gathering Line
Proposed West Gathering Line
Arctic National Wildlife Refuge
ExxonMobil
POINT
THOMSON
PROJECT
FACILITIES LAYOUT
ENVIRONMENTAL REPORT
NOVEMBER 2009
FIGURE 1-3



ExxonMobil

POINT THOMSON PROJECT

PIPELINE OVERVIEW

ENVIRONMENTAL REPORT

NOVEMBER 2009

FIGURE 1-4

2.0 ANALYSIS OF DEVELOPMENT COMPONENTS

National Environmental Policy Act (NEPA) and Council on Environmental Quality (CEQ) regulations for implementing NEPA (Section 1502.14) require that an Environmental Impact Statement (EIS) analyze a reasonable range of alternatives that meets the purpose and need of the proposed action. The proposed action and alternatives should be presented in a comparative form that sharply defines the issues and provides a clear basis for choice among options by the lead agency decision-maker.

The following analyses include alternatives considered and identify Exxon Mobil Corporation's (ExxonMobil) preferred action that has been selected for each component. Those preferred action alternatives are included in the Project Description, which for NEPA purposes, is the Proposed Action to be evaluated in the EIS. In Chapter 4, the environmental consequences of the Proposed Action are discussed by resource for drilling, construction, and operations.

2.1 APPROACH AND METHODOLOGY

In preparing development plans for Point Thomson, ExxonMobil evaluated a number of engineering options for Point Thomson Project (Project) components. These options were identified as the engineering process was advanced and as feedback was obtained from agencies and other interested parties through the pre-application consultation process. While a decision regarding each option must be made, each option does not necessarily have the same potential direct or indirect effects on the environment or on the practicability or viability of the project.

This section summarizes the evaluations of key component options for the Project. Each option that is included in the applicant's proposed Project Description is identified as a "Proposed Action" component.

The evaluation of options was conducted to determine if alternative component options met Project needs and should be considered further. This includes not only the overall Project purpose and need described in Section 1.4, but the related practical means necessary to successfully execute the component. In general, related Project needs include:

- Facilitate efficient reservoir development including drilling of wells and recovery of hydrocarbon resources;
- Promote personnel health and safety;
- Reduce adverse environmental effects; and
- Provide for efficient use of time, personnel, and space.

A two-level screening process was utilized. Some options that may meet project requirements but clearly had significant environmental drawbacks and/or unacceptable technological challenges were eliminated after a preliminary evaluation and were not subject to further consideration (see Section 2.2).

A second, more detailed, screening was conducted for other component options which either met or had high potential to meet Project needs. These component options were ranked or prioritized by level of importance in terms of Project practicability or potential environmental impact, e.g., Level 1 is a major project component that, if changed, would have a significant effect on other components or the overall Project or would result in a substantially different environmental impact. Level 1 options, if adopted, could significantly affect project cost and schedule. Level 2 component options may involve an impact on project schedule and cost or reduced environmental impact but would have a lesser effect than Level 1 options. The Proposed Action is identified for each option.

The evaluation in this section was designed to summarize and compare component options and document selection of the proposed option. The Project Description (ExxonMobil 2009a) provides more detail about the Proposed Action and is incorporated by reference into this analysis.

ExxonMobil will continue to evaluate Project enhancements during the NEPA and permitting processes, and changes may occur as these processes proceed. It is also expected that the Project team will solicit and incorporate Traditional and Local Knowledge (TLK), which may change Project components. The final Project permit applications will reflect changes to the project that result from TLK and NEPA processes.

2.2 COMPONENT OPTIONS ELIMINATED FROM DETAILED SCREENING

As discussed in Section 2.1, some component options were eliminated due to obvious Project practicability or environmental impact considerations. Some of the notable eliminated options are described below.

2.2.1 Well Pads on Barrier Islands

Earlier Point Thomson development plans located well pads on barrier islands as well as the mainland to allow the wells to access the reservoir. Advances in long reach directional drilling (LRDD) technology allow for horizontal departures on the order of 10,000 – 13,000 feet at Point Thomson, which allows all necessary drilling to occur from well pads located onshore near the coastline. Although well costs and drilling times could be reduced with drill sites on barrier islands, other drawbacks would offset these benefits. Offshore development would require pipelines buried in the ocean floor. Use of the barrier island for drilling sites would still require onshore infrastructure for processing fluids and other project support activities (e.g., airstrip, camps). Onshore well pads allow consolidation of facilities and relatively easy access between facilities. The option of offshore well pads was not considered further because of the increased environmental impact and Project practicability issues.

2.2.2 Solid Fill Causeway or Dock

Major North Slope facilities are constructed by fabricating modules and skids off-site and transporting those modules or skids to the field location for assembly and hook-up. The larger the modules, the greater the efficiency gained by off-site fabrication. Delivery of large modules to the field locations on the North Slope is done by large sealift barges, which necessitates the ability to offload the modules and transport them to their final location. The common and preferred method of offloading is to use Self Propelled Modular Transporters (SPMTs) to carry the modules from the barge to the facility location. In the case of offshore developments, such as Endicott or Northstar, the transport barges land directly at the facility and the modules are offloaded from the barge and driven into position by SPMTs. In the case of facilities located onshore, such as Prudhoe Bay or Kuparuk, transport barges offload the modules at a solid fill gravel causeway or dock extending into the Beaufort Sea. SPMTs transport those modules from the barge, across the causeway and adjoining roads, and onto the facility. The option of a solid fill causeway or dock was not considered further for the Project because a solid fill causeway or dock would result in significant additional environmental impacts and there are available options that are practicable for the Project without a causeway or dock.

2.2.3 Gravel Road Between Point Thomson and Deadhorse

Most North Slope oil and gas development relies upon gravel roads to provide year-round access for movement of equipment, materials, supplies and personnel. This was true for onshore developments, such as Prudhoe Bay and Kuparuk, and for the first offshore development (Endicott). This trend has not continued with the more recent onshore Badami and Alpine developments or at the offshore Northstar and Oooguruk developments. Similarly, early Point Thomson development plans considered a gravel road connecting the field with the Deadhorse/Prudhoe Bay area. Point Thomson is the most remote existing North Slope development and would require over 50 miles of gravel road to connect with the gravel road system in the Prudhoe Bay area. This option was not considered further because the inclusion of a road would result in significant additional environmental impacts and there are available transportation and logistic options that are practicable for the Project without the gravel road.

2.2.4 Export Pipeline Alternatives

The Proposed Action for the export pipeline is an insulated pipeline placed on vertical support members (VSMs) elevated a minimum of 7 feet above the tundra which is proven technology on the Alaska North Slope (ANS). The export pipeline would originate at the Point Thomson Central Pad. After being processed, the sales-quality condensate would flow through the export pipeline, which would connect with the common carrier pipeline at the Badami Development (22 miles west of the Central Pad) and ultimately to the Trans Alaska Pipeline System (TAPS). The inlet temperature of fluid in the export pipeline would be hot, approximately 150 degrees Fahrenheit (°F) (66 degrees Celsius [°C]).

Alternative pipeline configurations for the export pipeline from Point Thomson to Badami were considered including burial in the tundra and burial in the seabed of the nearshore area of the Beaufort Sea. Burial in the tundra has been evaluated for other North Slope projects and the nearshore buried pipeline design was suggested during the Point Thomson pre-application process. These design options, as discussed below, present significant technical, execution, operational, cost and environmental challenges that together make these design options not practicable for the Project. For each alternative configuration, a discussion of the unique technical issues is presented followed by the screening analysis of the alternative.

Two buried export pipeline alternative were considered and determined not to be practical: 1. On-shore Pipeline Buried on the Tundra, and 2. Offshore Pipeline Buried Near the Coastline.

Based upon preliminary screening analysis, neither of these options are practicable or warrant further extensive engineering analysis.

2.2.4.1 Technical Issues for Buried Warm/Hot Fluid Pipelines on the North Slope

Pipelines that transport warm or hot fluids generally cannot be buried in the North Slope tundra because the resulting heat transfer will cause melting and subsidence of the ice rich permafrost that is prevalent throughout the North Slope. This is true for either bare or insulated pipelines. The wellbore fluids will enter the gathering lines at approximately 180 °F (66 °C) and the export pipeline will receive product at about 150°F. Higher pipeline temperatures would result in a larger thaw bulb around the pipeline and a greater amount of subsidence.

Any subsidence of a pipeline poses a risk to the integrity of the line. Thaw subsidence along a pipeline segment would not be uniform and would result in differential settlement of the trench bottom. Under this condition, some portion of the pipeline would not be supported by the underlying soil, and the resulting pipe deformation threatens pipeline integrity, as well as causing additional alignment problems to drainage and groundwater cross-flow interruption. Buried pipelines must be monitored for trench subsidence and maintained on a continuous basis.

While it might be possible to chill condensate to sufficiently low temperatures to allow burial of the export pipeline, the export pipeline also needs to accommodate oil, which cannot be chilled to this temperature and still be pumpable. Therefore, it is not practical to bury the export pipeline.

The concerns with an uninsulated pipe also pertain to an insulated pipe. The pipe insulation merely reduces the rate of heat transfer to the surrounding soils, but will not prevent it.

2.2.4.2 Export Pipeline Buried in the Tundra

The export pipeline would be buried directly in the tundra along the alignment from the Central Pad to the Badami Development, where it would connect to the aboveground common carrier pipeline.

Benefits - This pipeline configuration would decrease visual effects (compared to an elevated pipeline) and should have no effect on humans and large animals crossing the alignment.

Buried pipelines will not interfere with subsistence hunting, whether along the coast or farther in-land.

Drawbacks - The technical challenges of constructing and operating such a pipeline are described in Section 2.2.4.1. In addition to those issues, other technical challenges include:

- Cross-drainage and drainage interception across the pipeline trench (the regional drainage is south to north and the pipeline alignment is generally east-west);
- Rehabilitation and revegetation of the pipeline trench (potential excessive settlement of the tundra over the ditch line due to tundra disturbance during construction and thermal influences); and
- Corrosion protection (water infiltration into the pipeline trench).

A pipeline buried in the tundra would have greater environmental effects than an elevated pipeline on VSMs (Proposed Action) because of the tundra disturbance during pipeline excavation and burial and any necessary excavation of the pipeline for detailed external inspection and maintenance.

2.2.4.3 Design Considerations Specific to Offshore Buried Pipelines in the Beaufort Sea

Offshore pipelines buried in the Beaufort Sea face design, execution and operational challenges unique to the offshore environment, in addition to most of the typical ANS onshore challenges. Strudel scour is a major offshore design consideration. It occurs during the spring when floodwaters from the rivers over-flood the sea ice. The floodwater flows through holes in the sea ice and, given the right conditions, creates scour holes in the seafloor. The size of the strudel scour hole that can occur is affected by many different factors, including amounts of floodwater and water depth. Strudel scour is a potential hazard to pipelines, because it can remove soil from around a pipeline and cause an unsupported span, which jeopardizes the integrity of the pipeline. Burying a pipeline deeper would help provide additional protection from strudel scour.

Ice gouging is another consideration for offshore buried lines. Ice-pressure ridges contacting the seafloor and plowing through the soil cause ice gouging. A pipeline could be affected by ice gouging in two ways: an ice keel could directly contact the pipeline or an ice keel could displace the soil around the pipeline. The size of an ice gouge is a function of many different factors, including water depth. In general, the potential depth of an ice gouge increases with water depth. Burying a pipeline deeper would help to protect it from an ice keel.

Winter construction offshore has the potential to adversely impact marine mammals that use the coastal areas and polar bears denning onshore along the coast.

Thaw settlement for offshore pipelines also presents unique challenges compared to onshore pipelines. Thaw settlement would be a concern unless the entire pipeline is constructed in thaw stable soils. It would require extensive geotechnical surveys to determine whether there are areas of thaw-unstable permafrost along the pipeline route. In addition, there will be permafrost transition zones (changes in the depth of the permafrost table near the shore) where the routing crosses the shoreline that may cause pipeline construction and integrity issues as well as erosion.

2.2.4.4 Export Pipeline Buried Offshore Near Coastline

This case assumes that the pipeline would be buried in the Beaufort Sea close to the coastline and would operate as a “hot” pipeline. There are currently two examples of subsea pipeline installations on the North Slope of Alaska: BP Exploration (Alaska)’s (BPXA) Northstar Development and Pioneer’s Oooguruk Development. These pipelines take production from offshore developments directly to shore on an alignment that intercepts the coastline at right angles. Although these pipelines provide important design and operational experience, they are not directly analogous to the Point Thomson offshore alternative since they are much shorter in length and there was no other practicable alternative to burying the pipelines in the seabed.

Benefits – The buried offshore export pipeline would reduce disturbance to terrestrial wildlife and visual esthetics, and would slightly decrease the overall land-based footprint of the Project. A buried offshore pipeline would allow unimpeded large-mammal movements across the field and would not interfere with subsistence hunting, whether it is land-based or boat-based along the coast.

Drawbacks – Installation of offshore pipelines would cause changes to seafloor sediments and suspension of sediments that result from trenching for the pipeline. Specific issues associated with this pipeline configuration include:

- Risk of damage to the offshore pipeline from ice gouging, strudel scouring, permafrost melting (thaw settlement), and upheaval buckling;
- Design issue for pipelines that traverse the near shore transition zone (where the permafrost table rises as it approaches the shore) – a nearshore line routing parallel to the shore would possibly include crossing and numerous such zones;
- Leak detection would be more difficult and preclude the effective use of visual detection;
- Extensive geo-technical data gathering would be required for offshore pipeline design to determine the composition of the substratum;
- Erosion control and shoreline crossing transition in the area where the pipeline crosses the shoreline may cause instability; and
- Offshore versus onshore oil spill response and clean-up with greater potential for environmental consequences from a marine spill.

Conclusion – A buried nearshore pipeline particularly when onshore options are available is not practicable with respect to meeting the needs of the Project and reducing environmental impacts.

2.3 PROJECT DEVELOPMENT COMPONENTS

The project component alternatives that were evaluated in more detail and are discussed in this section are:

Level 1 Options

- Well Pad Locations for Reservoir Development
- Large Module Delivery
- Pipelines
- Infield Road Development

Level 2 Options

- East Pad Options
- Power Facilities
- Flare Systems

2.3.1 Well Pad Locations for Reservoir Development (Level 1 Option)

A goal of the Project is to establish a design footprint which will facilitate development of the reservoir and delineation of the hydrocarbon resources of Point Thomson with the least environmental impact. This requires drilling wells to reservoir targets across widely separated locations and injection of gas back into the reservoir at other strategic locations. To drill these wells, it is necessary to construct gravel well pads (often called drill sites) at locations that allow drilling wells that reach the reservoir targets within the current capabilities of LRDD. The primary consideration for the analysis of well pad location options is how effectively an option supports full and effective reservoir development (reservoir targets) while at the same time reducing environmental effects.

Two reservoir development (RD) options are discussed in Sections 2.3.1.1 through 2.3.1.3 below. The Thomson Sand reservoir is located both offshore and onshore at Lion Bay but most of the reservoir lies offshore (Figure 1-2). LRDD technology enables some flexibility in selection of surface drilling locations while still meeting the reservoir development needs.

2.3.1.1 Option RD-1: Drilling/Well and Facility Pads Onshore, Along the Coast (Proposed Action)

Option RD-1 would locate pads onshore and near the coastline to develop the Thomson Sand Reservoir. Three pads (Central Pad, East Pad, and West Pad) are proposed for this option (Figure 1-2). To achieve effective development of the reservoir using three pads will require drilling world class wells that are at the edge of the envelope of existing directional drilling technology and experience for the depth and pressures of the Point Thomson Sand Reservoir. The environmental impacts of the well pads are mitigated by using existing gravel pads for portions of two well pads (East and Central Pads) thereby reducing the amount of new gravel footprint. The West and East Pad locations have sufficient set back from the coast to accommodate projected coastal erosion without the need for slope protection.

Benefits – The Thomson Sand Reservoir can be delineated, developed, and produced from the mainland using LRDD and three centralized well pads. LRDD has two benefits in this case: 1) it allows access to offshore reservoir areas from onshore well pads and 2) it minimizes the number of pads required. Locating the proposed project pads adjacent to the shore allows for the use or partial use of existing exploration gravel pads (Point Thomson Unit [PTU] #3 and North Staines #1). It also reduces the LRDD distance and thus drilling time and costs.

Drawbacks – Although LRDD makes this scenario possible, it has limitations. Drilling pads must be located at or very near the shoreline. Coastal wetlands and near-shore terrestrial habitat would be impacted. There could be a greater potential for polar bear interaction with this option than a site located further inland, because there is some movement and denning of polar bears along the coast line. Closer proximity to the coast could increase the chances of a spill reaching marine waters. The pads may be more visible from the ocean side and closer to subsistence hunters transiting along the shoreline in boats.

2.3.1.2 Option RD-2: Drilling/Well and Facility Pads Onshore, Inland from the Coast

Option RD-2 is similar to RD-1, except the East and West well pads would be located a mile or more inland from the coast. As shown in Figure 1-2, most of the reservoir is located offshore. If the pads are moved a mile or more inland, large areas of the reservoir could not be reached using current LRDD technology. The Central Pad and the East Pad will incorporate existing gravel pads thereby reducing the need for a new gravel footprint. The PTU-15 and PTU-16 wells are being drilled at the Central Pad and a Class I disposal well is planned to be drilled there in 2010. These wells are key elements of the Project plans.

***Benefits* –** Impacts to the coastal habitats may be reduced although the footprint of the pads would be the same as in RD-1 and it may not be possible to incorporate any existing gravel footprint into the pad. Potential encounters with polar bears may be reduced.

***Drawbacks* –** Because of the location of the Thomson Sand Reservoir and the limitations of LRDD, this option would not allow for effective delineation and development of the reservoir. Space for additional wells are included in the design of the well pads to provide a flexible footprint for future reservoir evaluation and development. Movement of the pads inland would be inconsistent with that need and limit reservoir development. The environmental impact trade-offs of moving pads inland need to consider the respective values of the habitats involved and the increase in new gravel footprint by not reusing existing gravel pads.

2.3.1.3 Reservoir Development Options - Summary and Conclusion

RD-1 was retained as the Proposed Action because it allows effective development and delineation of the Thomson Sand reservoir. The PTU-15 and PTU-16 wells are being drilled from the Central Pad, the Class I disposal well will be drilled at the pad in 2010, the planned layout accommodates additional well slots, and the existing Central Pad allows consolidation of facilities on a single pad (efficiently combining drilling, production and support functions), so moving the Central Pad is not practical.

There would likely be no significant reduction in environmental effects by moving the well pads inland. The pad sizes would remain the same but there would be a larger “new gravel” footprint. Unless there were significantly different value wetlands involved, the habitat/wetland effects would be similar.

Current LRDD limits for the project (dictated by reservoir characteristics and drilling capabilities) do not allow moving the onshore well pads inland any significant distance without impacting the basic purpose and need of the Project. RD-2 was not retained for further consideration because it would not meet the Project need of effective development of the reservoir.

Results of the evaluation of reservoir development options are presented in Table 2-1. The Project Description (ExxonMobil 2009a) presents further details regarding the proposed options for development.

TABLE 2-1: SUMMARY OF RESERVOIR DEVELOPMENT OPTIONS ANALYSIS

Field Development Options	Basis for Decision
RD-1. Drilling/well and facility pad(s) onshore, adjacent to the coast (Proposed Action)	• Requires least amount of new gravel footprint. • Only option that provides for effective reservoir development and delineation. • LRDD technology exists to access reservoir targets.
RD-2. Drilling/well and facility pad(s) onshore, inland from coast	• Reservoir cannot be optimally developed or delineated. LRDD technology does not allow reaching all reservoir targets. • Would require larger amount of new gravel footprint.

2.3.2 Large Module Delivery (Level 1 Option)

The Project needs include the means to transport large modular facilities that must be transported by sealift barges to Point Thomson during the construction phase. As discussed in Section 2.2.2, these large modules would be fabricated off-site and shipped by barge to the ANS. There is no existing or planned gravel road between Point Thomson and the existing Prudhoe Bay infrastructure that could be used to transport large modules.

To meet the Project's need to transport large modules, four transportation (T) options were identified:

- T-1: Sealift Transport to Dockhead 2 (West Dock) at Prudhoe Bay, Existing Gravel Road to Endicott Causeway and Sea Ice Road Transport to Point Thomson.
- T-2: Sealift Transport to Point Thomson Module Offloading Pier.
- T-3: Sealift Transport to Grounded Barge Bridge at Point Thomson (Proposed Action).
- T-4: Sealift Transport to Badami Dock and New Gravel Road to Point Thomson.

As discussed in Section 2.2.2, a solid fill causeway or dock similar to what was used at other North Slope developments was eliminated from consideration without detailed evaluation.

2.3.2.1 Option T-1: Dockhead 2 (West Dock), Gravel Road to Endicott Causeway and Sea Ice Road Transport of Large Modules to Point Thomson

Option T-1 would allow transporting sealift modules from the point of fabrication to Point Thomson using the following combination of facilities and activities:

- Use of Dockhead 2 (West Dock), located on the Prudhoe West Dock Causeway with some dredging or screeding and some dock modifications (within the scope of existing permits) for offloading the modules;
- Use of the existing Prudhoe Bay gravel road system from West Dock for module transport to a temporary storage location in the Prudhoe Bay area. Some expansion of existing roads and pads may be required;
- Construction of an ice road across the west channel of the Sagavanirktok River;
- Use of the existing gravel road to the Endicott Causeway; and
- Construction of a 50-mile-long, sea ice road from the Endicott Causeway to Point Thomson during the winter.

Benefits – This option allows transporting modules as large as 2,500 tons*.* Access to Point Thomson would use existing North Slope facilities with some upgrades and a constructed sea ice road to transport the modules from the Prudhoe Bay area to Point Thomson. This option reduces impacts at Point Thomson by eliminating the need to construct a pier or other system for offloading modules from barges. Option T-1 would eliminate large module-movement-related construction activity immediately onshore and offshore of Point Thomson, thus minimizing associated environmental impacts associated with large barge transit to Point Thomson as discussed below.

Drawbacks – Facilities in the Prudhoe Bay area may need to be upgraded or expanded to handle the large modules, potentially requiring some new gravel footprint. There would need to be dredging or screeding (leveling) and dock improvements at Dockhead 2, existing roads would need to be widened for the modules, and the ice roads would need to be thicker and sized to handle the heavy loads of the large modules. This option would limit the size of modules that could be handled to about 2,500 tons, which requires handling more modules and more on-site assembly and hook-up work. This option also imposes schedule and other risks to the Project due to the double handling of the large modules and availability of the ice road which can be affected by weather, coastal ice conditions and wildlife issues (e.g., presence of polar bears and dens).

2.3.2.2 Option T-2: Sealift Transport to Module Offloading Pier

Option T-2 would involve driving piles into the seafloor to construct a pile-supported marine off-loading facility (i.e., a pier) that would allow the direct transport of modules up to 3,000 tons via barge sealift to Point Thomson. Because the marine pier would be of pile-type construction, there will be limited dredging or screeding of the sea bed. The piling would be driven in the winter period and limited to shallow, near shore waters. Consideration was given to both trestle pier and decked pier concepts.

Option T-2A considered two finger-trestle piers by which modules would be transported by skid rail, as shown in Figure 2-1. The pier would extend from the shoreline to a water depth of 6 feet. A gravel ramp would be constructed from the Central Pad to the shoreline, where a sheet-pile bulkhead would be constructed. The modules would be transferred from the pier rails to SPMTs at the bulkhead. In addition to the finger piers, two offshore dolphins would also be installed to breast the off-loading barges against.

Option T-2B involves construction of a fully decked pier that can support SPMTs driving the modules directly off the barges, onto the pier, and subsequently onto shore-side facilities, as shown in Figure 2-2. The decked pier would be 35 feet in width and also extend to a water depth of 6 feet. The pier would end at the onshore bulkhead. A concrete deck surface would be used.

Benefits – This option reduces the schedule and other risks caused by double handling of the large modules and ice road transport to Point Thomson and would allow for modules as large as 3,000 tons to be transported, thereby reducing some onsite assembly and hook-up requirements. The marine pier facility would also reduce dredging, expansion of roadways and pads, and other required upgrades to facilities at Prudhoe Bay. Once installed, the pier could be used to transport other materials and equipment needed in future years via sealifts.

Drawbacks – This option would not accommodate barges loaded with 4,000-ton modules and would require the installation of piling for the piers and dolphins. Reduced module size would increase the number of barge trips required and increase the complexity of completing construction. The piles to support the pier would increase environmental effects when compared to the grounded-barge bridge option.

2.3.2.3 Option T-3: Sealift Transport to Grounded Barge Bridge (Proposed Action)

Option Sealift T-3 would involve temporarily grounding barge(s) to create a dock facility at Point Thomson, as shown in Figure 2-3. To provide a smooth surface for the grounded barge(s), some dredging and screeding (leveling) of material would occur. The area to be dredged is approximately 150 feet wide by 400 feet in length, starting at approximately 60 feet from the shoreline directly in front of the abutment (Figure 2-4). Based upon current bathymetry data, it is estimated that up to 1,500 cubic yards (cy) of excess material may need to be removed. The material could be distributed on the beachfront in a swath 20 feet wide by 1,000 feet long by 2 feet deep (assuming the maximum 1,500 cy) with placement determined in consultation with the applicable agencies.

SPMTs will be used to off-load the modules from the barges and then transport the modules across an onshore bulkhead and gravel ramp to the Central Pad. The onshore bulkhead will be constructed above the water line, as shown in Figure 2-4, to accommodate a ramp connecting to the barge grounded just off the shoreline. The deck of the barge at the bulkhead will be at an elevation of approximately 22 feet and a gravel ramp will provide the transition to the final grade of the Central Pad at approximately 12 feet (Figure 2-5).

The first barge to be offloaded will have a capacity of 1,500 tons because the barge draft must accommodate the average 5-foot water depth near the shoreline where it will be ballasted and grounded on the existing seabed. The barge will be secured to a breasting dolphin to resist any local movement during off-loading operations.

After the first barge is unloaded, the second barge will be navigated into position directly behind the first barge and also will be ballasted and grounded on the existing seabed. This second barge will have the capacity to carry 3,000 tons of modules at this 6.5-foot water depth. Similarly, the third barge will be placed directly behind the second barge and ballasted and grounded on the seabed. This third barge will have a capacity to off-load up to 4,000 tons of modules. The relative positions of the three barge bridges are shown in Figure 2-3. The first and second barges will remain in place until the off-loading operation is complete while the remaining barges will rotate through the third position as it becomes available. It is anticipated that the entire off-load sequence will take approximately 10-14 days. Upon completion of off-load, the barges will be re-floated and depart the area.

Benefits – This option allows transporting the largest module size and reduces the logistical risks caused by winter transport of large modules over ice roads to Point Thomson. The option would reduce dredging, expansion of roadways, and other required upgrades to facilities at Prudhoe Bay, and eliminate the double handling of modules and sea-ice road logistical risks.

Once installed, the onshore bulkhead and breasting dolphins could be used to transport materials and equipment needed in future years via sealifts. The duration of use is short (approximately 14 days) and only the breasting dolphins remain in the marine environment.

Drawbacks – The use of the grounded barge bridge concept requires the installation of the onshore bulkhead, breasting dolphins, and minor dredging. Once the barges are gone, the breasting dolphins would remain in place.

2.3.2.4 Option T-4: Badami Dock

Option Sealift T-4 involves upgrading the existing dock at the Badami Development to accommodate the 105-foot by 400-foot sealift barges, construction of a 15±-mile gravel road from the existing facilities at Badami to the West Pad of Point Thomson, and widening the 4.2 mile infield gravel road from West Pad to Central Pad by three feet (from 32 feet to 35 feet wide). The result of the additional gravel road and road widening would be increased gravel footprint size, use of additional gravel, and design and construction of eight new bridges and associated culverts. Modules would be off-loaded at the existing Badami dock and then transported using SPMTs over the gravel road to Point Thomson. Off-loading modules would require screeding (leveling) at the dock face to smooth out the seabed for grounding of the barges.

While there could be a sub-option (variant) to use the existing Badami dock in conjunction with an ice road from Badami to Point Thomson, this option would be similar to Option T-1. Instead of upgrading the existing West Dock, the Badami dock option would require more extensive upgrades. Similarly, it would likely be necessary to install additional gravel pad space at Badami for storage of modules. Due to the similarities of T-1 and this potential sub-option, no further work was done.

Benefits – Option T-4 uses existing Badami facilities to support development of Point Thomson thereby avoiding any new marine structures. If a gravel road were installed, it might be possible to use the airstrip at Badami to support Point Thomson which could eliminate the need to constructor reduce the size of a new airstrip at Point Thomson.

Drawbacks – Installation of the gravel road between Badami and the West Pad, along with widening the road from West Pad to Central Pad, would result in an increase in gravel-filled tundra footprint. Additionally, numerous streams would be crossed by the access road.

Summary and Conclusion – While Option T-1 is a viable approach for the movement of smaller modules, it is less able to meet Project needs and increases environmental impacts compared to Options T-2 and T-3. Option T-1 would result in more complex logistics with reduced module sizes. Options T-2 and T-3 both eliminate the need for additional gravel placement in the Prudhoe Bay area and have similar environmental impacts in the Point Thomson area. Neither T-2 nor T-3 are expected to have material impacts on marine mammals, fish, and interference with subsistence activities. Effects of these options would be largely limited to winter installation of piling and dredging over grounded ice and localized impacts during the period of barging module off-loading. However the breasting dolphins would remain in place. T-2 and T-3 provide the least risk for Project execution, and T-3 allows larger modules to be delivered than T-2. Option T-4 would involve significant environmental impacts due to the additional gravel footprint. Results of the evaluation of large-module delivery options are presented in Table 2-2.

Option T-3 is the Proposed Action because it would simplify logistics, reduce execution risk, reduce environmental effects, and allow the largest modules to be delivered. Option T-1 is to be retained as a contingency in the event that some modules are not able to be delivered in time for the large barge transport.

TABLE 2-2: SUMMARY OF SEALIFT ANALYSIS

Sealift Development Options	Basis for Decision
T-1. Use Prudhoe Bay West Dock and ice road to transport large modules from Prudhoe Bay to Point Thomson.	• Schedule risks from ice road use and double handling. • Minimizes disturbance to shoreline and marine environment. • Requires upgrades to Dockhead 2 (covered under existing permits) and upgrade of gravel road system. • Requires construction of a heavy-duty ice road from Endicott to Point Thomson. • Reduced size of modules due to ice road limits.
T-2. Construct pier at Point Thomson to support marine off-loading facilities to facilitate the transport of large modules.	• Decreases schedule and logistical risks. • Minor environmental impacts to fish and marine species • Allows for more efficient transport of large modules to Point Thomson. • Allows for improved future barging access to Point Thomson.
T-3. Install a grounded barge bridge at Point Thomson to facilitate the off-loading of large modules via a sealift operation at Project site. (Proposed Action)	• Decreases schedule and logistical risks • Minor environmental impacts to fish and marine species • Allows for more efficient transport of large modules to Point Thomson. • Allows for improved future barging access to Point Thomson.
T-4. Upgrade the existing Badami dock.	• Requires a gravel road between Badami and West Pad, and widening of road from West Pad to Central Pad • Requires eight additional bridges and additional culverts along new gravel road

2.3.3 Pipelines (Level 1 Option)

Project pipelines will transport three-phase produced fluids from the production wells at the East, West, and Central Pads to the Central Processing Facilities (CPF) on the Central Pad, transport compressed gas from the CPF to the injection wells for re-injection into the reservoir, and transport condensate and oil to the common carrier pipeline at Badami, and ultimately to the TAPS. To meet these needs, the Project includes two 8-inch gathering lines from the East and West Pads to the CPF, a local gathering line from the Central Pad producing well to the CPF, a local gas injection line from the CPF to the Central Pad injection well, and one 12-inch common carrier export pipeline from the CPF to the Badami tie-in, as shown on Figures 2-6 through 2-9.

Section 2.2.4.1 discusses technical issues with burying pipelines that transport warm or hot fluids in the tundra and why buried gathering lines buried in the tundra were not considered further. While burial of chilled pipelines may be practical, mechanical chilling of the gathering lines to prevent permafrost thaw is not practical. Hydrates will form in the three-phase stream gathered from the well pads at temperatures below approximately 80°F (27°C). These hydrates form a solid plug, which would prevent flow through the pipeline.

The export and gathering pipelines are routed within areas used for subsistence hunting by Kaktovik and Nuiqsut residents, and the design of these pipelines will consider the potential for accidental bullet strikes. The design will consider rifle calibers and ammunition typically used in the area for caribou hunting and will incorporate additional wall thickness if necessary to prevent penetration from accidental bullet strikes fired from the coastline where the majority of hunting occurs.

Buried pipelines are more difficult to inspect and visual inspection requires excavation. Some pipeline failures have occurred in underground sections of pipe which are analogous to buried lines from a corrosion perspective (caribou and road crossings). Risks of buried pipeline integrity resulting from settlement, water collection and corrosion are a concern. Generally, pipelines on the North Slope are not buried for these critical reasons.

Results of the evaluations of in-field pipeline options and the export pipeline are presented.

2.3.3.1 Export Pipeline: Options EP-1 and EP-2

The export pipeline would originate at the Point Thomson Central Pad. The sales-quality condensate would flow through the export pipeline, which would connect with the common carrier pipeline at the Badami Development (22 miles west of the Central Pad) and ultimately to the TAPS. The inlet temperature of fluid in the export pipeline would be hot, approximately 150°F (66°C).

No permanent roads are located along the export pipeline route between Point Thomson and Badami. Therefore, burial in a road, as considered for the gathering lines, is not an option for the export pipeline.

Buried pipelines on shore in the tundra or offshore in the bed of the Beaufort Sea are not considered practicable for the Point Thomson Project, as discussed in Section 2.2.4.

Two export pipeline (EP) options were identified:

- EP-1: Export pipeline elevated on VSMs (Proposed Action).
- EP-2: Export pipeline elevated on VSMs inland from the coast.

<u>Option EP-1: Export Pipeline Elevated on VSMs (Proposed Action)</u>

Option EP-1 would be an insulated, elevated export pipeline installed on VSMs. From the Central Pad, the export pipeline will be supported on the same VSMs that hold the gathering line from the West Pad, as shown on Figure 2-10. Where the gathering line turns in a northerly direction to the West Pad, the export pipeline continues in a westerly direction toward Badami on the VSMs, as depicted on Figure 2-11. The export pipeline is located approximately 1 to 2 miles from the coast until turning north to tie into the common carrier pipeline at Badami, for a total distance of 22 miles. The VSMs will provide a separation of at least 7 feet between the bottom of pipe (including any associated power/telecommunications cables or vibration arrestors) and the tundra surface.

As discussed in Section 2.2.4.1, installing elevated warm or hot pipelines on VSMs is far preferred over buried pipelines in permafrost areas. The pipeline would allow free passage by wildlife and subsistence hunters on snow machines. Pipeline inspections would more readily detect leaks, thereby reducing the effect of any spilled oil. Aboveground pipelines on VSMs are a proven practice and the most common pipeline option on the North Slope. There would be minimal tundra disturbance from VSMs installed from ice roads during the winter. No hydrologic impacts to tundra streams are anticipated since VSM location and spans will consider stream locations and break up and other peak stream flows.

Benefits – This routing minimizes pipeline length and thereby minimizes the direct environmental impacts associated with construction and maintenance.

Drawbacks – This option has a greater visual effect from the coast and increases concerns related to subsistence hunting and caribou migration along the coast. Subsistence hunters often hunt from boats along the shore in the Point Thomson area, and this pipeline routing may cause concerns for local hunters regarding hunting and caribou movement. It may also require the pipeline wall thickness be increased to address potential bullet strikes. Winter construction has a greater potential of disturbing denning polar bears than a further inland option.

Option EP-2: Export Pipeline Elevated on VSMs Inland From the Coast

Option EP-2 would move the export pipeline further inland from the coast. This option is similar to Option EP-1, except the pipeline will be longer and farther inland.

Benefits – The benefits of locating the export pipeline further away from the coast include:

- reduced potential polar bear interaction during construction and maintenance;
- reduced potential caribou impacts with regard to insect relief habitat;
- reduced potential conflicts with subsistence hunting; and
- reduced visibility from the coast.

Drawbacks – Pipeline lengths would increase, causing a greater Project footprint and construction costs. EP-2 would locate the pipeline further inland, which may reduce, but not eliminate, a minor impediment to humans and large animals crossing the alignment. While the more inland routing may better avoid caribou insect relief habitat, it may also encroach on higher density caribou calving habitat. The more inland routing would preclude sharing more than 3 miles of VSMs with the gathering line between the Central and West Pads and involve additional pipeline routing/right of way.

Summary and Conclusion

EP-1 is the proposed action. There are functional and environmental trade-offs between EP-1 and EP-2 (see Table 2-3). The drawbacks identified with EP-1 are, to some degree, mitigated with the proposed design. EP-2 would impact a larger amount of North Slope habitat and result in more significant costs.

TABLE 2-3: SUMMARY OF EXPORT PIPELINE OPTIONS ANALYSIS

Export Pipeline Options	Basis for Decision
EP-1. Export Pipeline elevated on vertical support members approximately 1-2 miles from the coast (Proposed Action)	• Proven technology; shorter pipeline length • Increased concerns regarding subsistence hunting • Increased concerns regarding impacts to caribou insect relief habitat
EP-2. Export pipeline on vertical support members located further inland from coast	• Proven technology; longer pipeline length • Mitigates concerns regarding subsistence hunting • Increased concerns regarding impacts to caribou calving habitat

2.3.3.2 Gathering Lines: Options GL-1, GL-2, and GL-3

Gathering lines would carry a three-phase fluid stream produced from the East and West pads to the Central Pad, as shown in Figures 2-8 and 2-9. The gathering lines will be hot, approximately 180°F, and as described in Section 2.2.4.1, gathering lines buried in the ice rich permafrost underlying the tundra are not practical or feasible. It might be feasible to bury gathering lines in the thaw stable gravel used to construct the infield gravel roads.

For this analysis, three potentially feasible gathering lines options were identified:

- GL-1: Gathering lines buried in the gravel road at the centerline (insulated).
- GL-2: Gathering lines buried in the gravel road at the shoulder (insulated).
- GL-3: Gathering lines elevated on VSMs (Proposed Action).

Options GL-1 and GL-2 Gathering Lines Buried in the Gravel Road

GL-1 and GL-2 present options for gathering lines buried in the roadbed and have similar environmental and operational concerns, and the two options will be evaluated together. GL-1 is a pipeline buried in the center of the roadbed and GL-2 has the pipelines buried in the shoulder of the road. Properly constructed, the gravel roadbed itself is thaw-stable. The tundra below the pipe can thaw if the pipeline is at a high enough temperature, so protection of the underlying tundra must be considered. Buried gathering lines must:

- Control and limit thaw settlement along the entire length of pipeline, which requires controlling or eliminating thaw of the permafrost;
- Have a cathodic protection system;
- Have an external coating; and
- Ensure structural protection of the pipe.

Benefits – Gathering lines buried in the road would minimize disturbance to wildlife and visual esthetics and would slightly decrease the overall footprint of the Project by merging the pipeline corridor with the roadway. Buried pipelines would allow unimpeded large-mammal movements. In addition, buried pipelines would not interfere with subsistence hunting, whether it is land-based or boat-based along the coast.

Drawbacks – It may not be feasible or practical to bury a warm or hot pipeline in a road and sufficiently control thawing of the underlying permafrost to ensure pipeline integrity. GL-1 would limit the load capacity for the in-field roads to prevent crushing, and subsequent degradation, of the pipe insulation. Standard truck loadings are likely not a significant issue for rigid insulation materials; however, drill rig movements would not be possible without significantly increasing the road thickness.

GL-2 would require more gravel then a standard gravel road, because the shoulder would have to be expanded. This expansion increases the gravel footprint. This would, however, move the pipeline out of the traffic lanes and potentially increase the road carrying capacity.

For either option, the long-term integrity of the insulation material could also be a significant consideration. Corrosion under insulation is a known cause of North Slope pipeline leaks.

Buried pipelines are more difficult to inspect, maintain, and repair and visual leak detection is compromised by the burial. Recent pipeline failures have occurred in underground sections of the pipeline (e.g., at caribou or road crossings) and the leaks were not detected until substantial volumes of oil were spilled. Generally, pipelines on the North Slope are not buried for these critical reasons. Burial of the pipelines in the road would make it more difficult to add pipelines or capacity for future expansions of the field.

In summary, GL-1 and GL-2 present a pipe integrity threat because of thaw settlement, increased corrosion and difficulties of monitoring corrosion, and leak detection. Both options raise questions as to the long-term viability of the insulation systems. Both options are much more complicated to install, maintain, and operate than Option GL-3.

Option GL-3: Gathering Lines Elevated on VSMs (Proposed Action)

The gathering lines in Option GL-3 would be insulated and installed on elevated VSMs.

Benefits – Aboveground gathering lines would be elevated to 7 feet above the tundra, allowing unimpeded wildlife passage, as shown in Figures 2-10 and 2-12. Subsistence users moving through the field would have clearance to pass under the pipeline while riding snow machines. Gathering lines would also be constructed with sufficient separation distance between the roads and pipeline to allow for unimpeded large terrestrial mammal movement. Aboveground gathering lines reduce the potential for undetected leaks and expedite oil spill clean-up. Spills can be discovered sooner than leaks from buried pipelines. Aboveground gathering lines on VSMs are a proven technology on the North Slope that allow for future development and expansion and are the most common pipeline option used.

Drawbacks – This option has a greater visual effect than a buried pipe and increases concerns related to subsistence hunting and caribou migration along the coast. Subsistence hunters often hunt from boats along the shore in the Point Thomson area, and an elevated pipeline may cause concerns for local hunters. Large terrestrial mammals moving across the alignment would have to pass under the pipeline.

Summary and Conclusion

Options GL-1 and GL-2 are not technically proven, have numerous technical and operational issues that would have to be resolved and therefore are not considered practicable. Table 2-4 summarizes functional and environmental trade-off between GL-1, GL-2, and GL-3. Option GL-3 would have visual impacts that can be mitigated with pipeline coatings. Large mammals would have to pass under the pipeline, but the seven foot clearance does not pose an impediment to such passage. Option GL-3 is the proposed action from a design, operation, maintenance, and spill prevention standpoint and has been proven to work on the North Slope. Threats from accidental bullet strikes are not expected to be a problem given the wall pipe thickness of the gathering lines.

TABLE 2-4: SUMMARY OF GATHERING LINE OPTIONS ANALYSIS

Gathering Line Options	Basis for Decision
GL-1. Gathering lines buried in the gravel road at the centerline GL-2. Gathering lines buried in the gravel road at the shoulder	• Additional gravel may be needed for GL-2, increasing footprint • Significant road upgrades to allow heavy load transport (e.g. drill rigs) with GL-2 • Leak detection is less reliable and visual inspection is compromised • Maintenance and repairs are more difficult • Decreases Project footprint associated with separate pipeline and road routings • Does not provide for future expansion
GL-3. Gathering lines elevated on vertical support members (Proposed Action)	• Proven technology • Provides for future expansion • Subsistence hunting concerns regarding bullet strikes mitigated by pipeline wall thickness • Wildlife migration effects can be mitigated through 7-foot construction height

2.3.4 Infield Road Development (Level 1 Option)

The Project requires a reliable means of infield transportation to allow for many activities to occur. Some of the essential ones are:

- Transporting personnel to each well pad on a daily basis to perform inspections, maintenance and repairs;
- Evacuation of personnel for medical or safety reasons;
- Urgent repairs to facilities required which left undone could pose an imminent safety or environmental hazard;
- Responding to oil spills and other incidents or emergencies in a timely manner;
- Transporting large equipment to the well pads to allow for necessary repairs to be made in a timely manner; and
- Transporting wastes, particularly large volume wastes such as drilling wastes, in a timely manner.

An infield gravel road system is an integral part of the development plan for the Project. The East and West Pads are essentially satellite drilling and production facilities which, as such, are not designed as stand alone self supporting units; they lack life support infrastructure such as camps, and other infrastructure that would allow for independent operation and control. Without installing infield roads, numerous aspects of the overall development would have to be reviewed and redesigned, which could lead to significant schedule delays.

All onshore North Slope oil and gas development projects, including those that lack road access to Prudhoe Bay infrastructure such as Alpine and Badami, have infield road systems linking drilling/production pads to centralized processing facilities and/or other support infrastructure. This development scheme has proven the most efficient and safe development scheme for Arctic oil and gas development.

Roadless development has been described by the National Petroleum Reserve-Alaska (NPR-A) 1998 EIS (Department of Interior [DOI] 1998) as facilities without permanent roads constructed along pipeline alignments connecting to existing infrastructure east of the Colville River. The Badami and Alpine facilities are considered roadless developments, using the NPR-A definition, because they are not connected by road to existing Prudhoe Bay operating areas. Point Thomson is also a roadless development under this definition. Such roadless development is a more recent trend on the North Slope, prompted by both environmental and economic concerns.

Roadless development facilities use ice roads and infield gravel roads within operating fields. Seasonal ice roads are used for transporting equipment and supplies between Point Thomson and the existing road system near Prudhoe Bay, and infield gravel roads typically connect production pads and facilities within individual fields.

Two in-field road development (RO) options were evaluated for this alternatives analysis:

- RO-1: Construct infield roads between the airstrip and Central Pad (approximately 2.2 miles total of gravel road). No infield roads from the East and West Pads to the Central Pad are constructed.
- RO-2: Construct infield roads at Point Thomson between the airstrip, Central Pad and East and West Pads (approximately 12 miles total of gravel road) (Proposed Action).

The primary considerations for analysis are habitat loss, disturbance, operational efficiency, safety, and environmental and emergency response. Results of the evaluation are discussed below.

2.3.4.1 Option RO-1: In-field Road between Central Pad and Airstrip with No Road to East and West Pads

This option would limit the gravel infield road system to the gravel road between the airstrip and the Central Pad. This road would be approximately 2.2 miles long, as shown on Figure 1-3. The East and West pads would be developed and accessed using onshore ice roads or sea-ice roads during the winter and by a combination of helicopters, hovercraft, all terrain vehicles, boats or other vessels, and other methods that could move people and personnel during the remainder of the year (approximately May through November or December).

Benefits – RO-1 would decrease the gravel footprint of the Project and change the nature of traffic between the pads when ice roads are not available. This would have the following environmental implications:

- reduction of wetlands impacts and related habitat loss;

- reduction in disturbance to wildlife from road traffic; and
- reduction in dust shadow effects caused by traffic adjacent to roads.

Drawbacks – Use of alternate methods of transportation to provide year-round access would have to be implemented (or increased) such as helicopters, hovercraft, all-terrain vehicles and boats. Routine operations and maintenance activities require personnel to make daily trips, at a minimum, to both the East and West Pads. Ice roads could fulfill this need in the winter and helicopter pads could be built adjacent to the well pads for year-round access. A dedicated helicopter and pilot would need to be stationed at Point Thomson during periods when ice roads were not being used. Boat ramps would also be required and gravel access ramps between the boat ramp and the pads would have to be constructed. Other means of transport such as all-terrain vehicles and hovercraft would be used as appropriate. Coastal fog conditions could prevent helicopters from flying during essential time periods and could make consistent travel difficult, thereby necessitating the need for alternatives. Response time in case of an emergency situation could also be hindered by coastal fog conditions during periods of the year when ice roads are not in use.

Logistical problems could arise if a large or heavy piece of equipment from one pad needed to be sent out for emergency repair. During winter, the ice road could be used to move equipment to the airstrip for transport. During the remainder of the year, equipment would need to be “slung” out using a helicopter. Some equipment is too large for helicopter transport. The same logistic problems could arise when equipment needed to be moved out to either East or West Pads.

If the East and West Pads were required to operate as satellite drilling and producing pads, it would be necessary to make the pads larger to accommodate seasonal logistical support needs. Additionally, space would have to be made for storage of drilling consumables and other supplies and equipment, and a camp.

The combined effects of helicopter, all-terrain vehicle, hovercraft, boats and other means would significantly increase the nature and amount of noise and disturbance to terrestrial birds, mammals, and subsistence activities in the area, compared to a similar level of road traffic confined to a single route.

2.3.4.2 Option RO-2: In-field Roads at Point Thomson with Connection to East and West Pads (Proposed Action)

Under RO-2, gravel roads to the East and West pads would be constructed as shown in Figure 2-14. The gravel road to the East Pad would be approximately 4.6 miles long, and would include the airport and water access road. The gravel road to the West Pad would be approximately 4.8 miles long.

Benefits – Construction of gravel roads to the East and West Pads would provide efficient, year-round access for operations, maintenance activities, and emergency response. RO-2 would involve minimal use of helicopter operation, thereby decreasing air emissions and noise disturbance and increasing safety of personnel. RO-2 would also simplify in-field transportation within the Point Thomson operational area.

Drawbacks – Construction of gravel roads would increase the overall gravel footprint of the Project, thereby increasing effects to tundra habitat and wetlands. There would be some dust production from road vehicle traffic.

Summary and Conclusion

While RO-1 would reduce some environmental impacts, it would increase others and introduce some new impacts. RO-1 is not the Proposed Action because it would increase health and safety concerns, constrain construction and operations at Point Thomson, increase noise impacts, and require intensive helicopter service and other alternative traffic methods.

RO-2 provides more efficient and safe in-field transportation options. Although impacts to wildlife are different between the two options, impacts from gravel roads in the North Slope area are generally understood. The impacts to wildlife caused by the potentially wide variety of personnel and equipment transportation may be more difficult to predict. The results of the evaluation of road options are presented in Table 2-5. The Project Description (ExxonMobil 2009a) presents further detail.

TABLE 2-5: SUMMARY OF INFIELD ROAD DEVELOPMENT OPTIONS ANALYSIS

Road Development Options	Basis for Decision
RO-1. Construct infield roads at Point Thomson between the airstrip and Central Pad. Do not construct infield roads from the East and West pads to the Central Pad.	• Increases in noise levels (helicopter use). • Increase in noise "footprint" due to multiple transportation modes that would be required • Increased safety concerns with more helicopter flights and emergency response needs. • Increase in East and West Pad size for storage and possible camp.
RO-2. Construct infield roads at Point Thomson between the airstrip, and Central Pad and East and West Pads and Central Pad. (Proposed Action)	• Allows safe, efficient access to pads for routine operations, maintenance, and emergency response • Minimizes disturbance from helicopters and other alternate transportation modes. • Increases gravel footprint and associated effects from roads.

2.3.5 East Pad Options (Level 2 Option)

As described in Section 2.2.1, inland alternatives were evaluated for pad locations as a Project option. Three different East Pad location options were also evaluated as an individual project component (sub-option).

2.3.5.1 East Pad Alternate Locations

The East Pad location was selected because it met reservoir development requirements summarized in Section 2.3.1 and provided the opportunity to reduce new gravel footprint by utilizing an existing gravel pad. There are several options for the specific location and configuration of the East Pad relative to the existing gravel pad. These options also have to be screened with respect to design criteria including 100-year ocean storm event, 100-year ice ride-up event, and shoreline erosion that may occur over a 30+ year project life. Three alternate locations were investigated, each using the North Staines River State No. 1 Pad to varying degrees.

2.3.5.2 East Pad Option EP-1

This option was described in the July 2009 Draft Project Description provided to the United States (U.S.) Army Corps of Engineers (USACE) on 7 July , 2009, and to other interested parties for pre-application consultations. It generally consisted of constructing a new gravel pad near the existing pad and incorporated a small portion of the North Staines River State No. 1 Pad.

Benefits – Project technical criteria were met and this was the preferred solution from an engineering and construction perspective.

Drawbacks – This option met the project technical design criteria but it did not minimize new gravel footprint because it incorporated relatively little of the existing gravel pad. In addition, this option would place the pad within 500 feet of a stream to the southeast of the pad location, which has been identified to be fish-bearing in Technical Report 04-03, *Fisheries Investigations in Streams Crossed by the Proposed Point Thomson Gas Cycling Plant, May 2004,* prepared by Jack F. Winters and William A. Morris (referenced as Stream A in report).

2.3.5.3 East Pad Option EP-2 (Proposed Action)

This option reduces the required new gravel pad footprint by locating the East Pad to use as much of the North Staines River State No. 1 Pad as practical while still maintaining the necessary setback from the shoreline as shown in Figure 2-15.

Benefits – The Project technical criteria are met by this option and the amount of new gravel footprint is reduced compared to EP-1 or a new, stand-alone gravel pad. Using the North Staines River State No. 1 Pad will decrease gravel required for the construction of the East Pad. It meets the shoreline setback design criteria and does not require slope protection.

Drawbacks – The pond to the northwest must be addressed in the gathering line layout as it approaches the pad. The pond immediately to the south would adversely impact the road alignment to the pad. There are uncertainties with the feasibility of drilling wells or installing piling for facilities foundations through the existing reserve pit (mound located along the westernmost edge of the North Staines River State No. 1 Pad). It will be necessary to work with the Alaska Department of Environmental Conservation (ADEC) on the approach to be taken with respect to the reserve pit. Construction over the reserve pit could require excavation and disposal of the pit contents before commencing gravel operations. This option will be more costly than EP-1 and may cause construction delays due to added permitting or regulatory complexities.

2.3.5.4 East Pad Option EP-3

Option EP-3 is similar to EP-2 except it would utilize a greater portion of the existing gravel pad. While this would further reduce the new gravel footprint required, the resulting pad would not meet shoreline setback criteria thereby requiring installation of shoreline protection to protect against erosion and ice pile-up and ride-up. A variety of options are available for shoreline and slope protection. This investigation assumed 4- cy gravel bags while an OPEN CELL® wall could also be considered.

Benefits - Using the entire North Staines River State No. 1 Pad will further decrease gravel required for the construction of the East Pad, decreasing the amount of new gravel footprint.

Drawbacks – The issues discussed in EP-2 with respect to the existing reserve pit also apply to EP-3. The addition of shoreline protection to mitigate the threat of erosion and ice ride-up and pile-up will increase costs. The presence of shoreline protection on the pad may cause additional shoreline erosion on adjacent shorelines that are not similarly protected. Hence, there are environmental trade-offs between utilizing more of the existing pad and causing enhanced erosion of adjacent, undeveloped wetlands.

Summary and Conclusion

Option EP-2 incorporates the existing pad and reduces new gravel footprint while still meeting Project technical requirements and is the proposed action. While more costly than EP-1, EP-2 is considered practicable from a Project perspective. EP-3 has questionable environmental benefits compared to EP-2 due to the potential for increased erosion of the adjacent coastline and it would be more costly.

2.3.6 Power Facilities (Level 2 Option)

At most North Slope oil field developments, electrical power is generated on site. Diesel-powered electrical generators are typically the initial power source used for drilling and during construction of facilities. Once available, produced gas is used to power on site electrical generators, and diesel is not used as the primary power source. On-site power generation provides reliable power and facilitates regular maintenance and access for emergency maintenance and repair. This is especially important in an environment like the North Slope, where loss of power could pose significant operational, health, and safety threats. The power requirements identified in the preliminary engineering work for the Project are estimated to be more than 18 megawatts (MW).

Power facility (PF) options identified were:

- PF-1: Use Badami spare capacity with additional power generation units installed either at Badami or Point Thomson; or
- PF-2: Install power generation units at Point Thomson (Proposed Action).

The primary considerations for selection are availability, capacity, and ease of power transmission to project facilities at Point Thomson. Results of the evaluation are discussed below.

2.3.6.1 Option PF-1: Utilize Badami Spare Capacity with Additional Power Generation Units Installed

PF-1 would use existing power generation facilities at Badami and supplement additional power needs with new generating facilities at Badami or Point Thomson. Power lines would be installed between Badami and Point Thomson to transmit electricity.

***Benefits* –** The Badami facility has two 9.0-MW power generation units. One power generator is operated at a time, and the other unit serves as a stand-by. Because of the critical nature of power, it is necessary to maintain stand-by capacity at all times. The Badami facility is currently shut in but some power is required to maintain the facilities in a warm shutdown status. There is a "redevelopment" program underway at Badami. Until this program is complete, it will be uncertain whether Badami has spare capacity that could be used at Point Thomson. For the purposes of this analysis, it is assumed that there would be some spare power that could be used at Point Thomson.

***Drawbacks* –** To use spare power capacity from Badami, a power line would have to be constructed between Badami and Point Thomson, regardless of the amount of spare capacity. This could potentially be placed on the export pipeline VSM or require a separate line. Constructing approximately 22 miles of separate power line - whether underground, installed on the VSMs or raised on towers would have potential environmental effects. Potential raised cable impacts include bird collisions with aboveground power lines, wind-induced power line damage, construction of tower pads, and interference with local resident subsistence activities and winter transportation. Underground lines would have some tundra impact and would be expensive.

For the Project to rely upon Badami power, it would be necessary to have a firm commitment of availability and it is unlikely this could be addressed until the Badami redevelopment program is complete.

2.3.6.2 Option PF-2: Install Power Generation Units at Point Thomson (Proposed Action)

Under PF-2, power generation units would be located on-site at Point Thomson and would provide all power generation requirements of the Project.

***Benefits* –** This option would eliminate the need to install a high power capacity transmission line from Badami to Point Thomson, eliminating environmental concerns associated with such a power line. It would be safer for personnel working at the site because possible power failures could be addressed more quickly and efficiently.

***Drawbacks* –** This option would require a small increase in gravel fill at Point Thomson for placement of the generators and could potentially increase noise levels at Point Thomson.

Summary and Conclusion

Potential use of minimal spare capacity from the Badami power facility does not provide sufficient advantage to justify the installation and maintenance of a power line to satisfy Project requirements. New power additions can most efficiently be installed at Point Thomson when production facilities are installed. Because of the uncertainty of available power from Badami, it is impracticable for the Project to rely upon such power. On this basis, PF-2 is the proposed action.

Results of the evaluation of power supply options are presented in Table 2-6. The Project Description (ExxonMobil 2009a) presents further details regarding power supply options for development.

TABLE 2-6: SUMMARY OF POWER FACILITY OPTIONS ANALYSIS

Power Facility Options	Basis for Decision
PF-1. Use Badami capacity with additional power generation units installed either at Badami or Point Thomson	• Requires new power generation units at Badami or Point Thomson. • Requires high capacity power line. • Increases adverse environmental effects. • Introduces Project risk and uncertainty
PF-2. Install power generation units at Point Thomson (Proposed Action)	• Eliminates need for power line. • Simplifies on-site maintenance. • Reduces overall environmental effects of power generation.

2.3.7 Flare Systems (Level 2 Option)

Natural gas will be the primary fluid produced from the wells and handled in the Project's gathering lines, plant, and gas injection system. The Project requires a means to safely remove and burn these gases when required for maintenance or when there is a temporary process upset or an emergency condition. Released hydrocarbons will first flow to flare knock-out drums, where liquids will be separated before the gas is sent to flare. There are two separate flare systems, one for high-pressure (HP) gases and one for low-pressure (LP) gases.

No routine flaring is planned at the Project site, other than the minor quantities of purge and pilot gas that are required for safe flare operations. Air emissions from the pilot and purge gas combustion will be included in the emissions inventory for the CPF. The Project will use one HP flare and one LP flare for disposal of plant relief flows during plant upset or shut-down. The maximum instantaneous gas flow rate to the HP flare system is expected to be approximately 250 million standard cubic feet per day (mmscfd). This scenario represents an emergency situation where produced fluids are vented at high rates from the inlet of the CPF. High-rate relief to the flare is a very rare occurrence. A more typical flaring scenario would be when an unplanned shutdown of an injection compressor occurs. The maximum LP flare gas rate is approximately 10 mmscfd and is based on a process upset in the condensate separation train or the unplanned shutdown of the low pressure flash-gas compression system.

2.3.7.1 Flare Options for Point Thomson

Three different types of flares have been considered for the Project. Each type of flare has unique characteristics, advantages, and disadvantages.

Three types of flare systems (FL) considered are:

- Option FL-1A and Option FL-1B: Elevated flare system
- Option FL-2: Enclosed flare system

- Option FL-3: Ground-based flare system

The primary considerations for selection of the flare system are the ability to meet the Project need to safely and efficiently burn gas when required, reduce visual impact to the Arctic National Wildlife Refuge area (hereinafter the Refuge) and visitors to the Project area, and reduce the potential environmental impact on the tundra and terrestrial wildlife. Results of the evaluation are discussed below.

2.3.7.2 Option FL-1A and Option FL-1B: Traditional Elevated Flare System (FL-1A Proposed Action)

Options FL-1A and 1B utilize a standard elevated flare system. Elevated flares consist of vertical risers mounted on VSMs and a flare tip mounted on top of the riser. Two configurations, FL-1A and FL-1B, are considered for the elevated flares.

The first configuration, FL-1A, uses separate risers for the HP and LP flares. The HP flare will have an approximate height of 120 feet or more. The LP flare will have an approximate height of approximately 40 feet or more. FL-1A is the proposed action.

The second configuration, FL-1B, uses a common riser for both HP and LP flares. The riser supports the HP flare tip and the LP flare is piggy-backed off the HP riser. The combined riser will be the same height as the HP flare in FL-1A.

The flare tip heights are required to limit radiation intensity at the base to a level that is safe for operating personnel or for wildlife that may enter the area to seek shelter or safely exit without being harmed.

Benefits – The elevated flare stack will have minimal visual impact, except during actual flaring events, as the riser diameter is small. The elevated flares have the smallest overall footprint. The combined flare in FL-1B will have approximately half the footprint of the separate HP and LP flares in FL-1A. With either of these options, the disturbance to the tundra will be less than for FL-2 or FL-3. The elevated flare system is expected to require the least site construction effort and consequently minimal environmental impact during the construction phase.

Drawbacks – The height of the elevated flares will make them more noticeable during actual flaring events. The combined flare option, FL-1B, may have higher visibility during flaring events which involve both the HP and LP flares. The noise level during flaring events will be higher for FL-1A and FL-1B than with FL-2 and FL-3.

2.3.7.3 Option FL-2: Enclosed Flare System

Enclosed flares use flare tips enclosed in refractory-lined vertical carbon steel vessels. The combustion process and flame are contained completely within the vertical vessel. The HP flare will require three large diameter vessels (35-feet to 40-feet in diameter or greater) and a minimum of 90-feet tall, and the LP flare will require an additional 20-feet plus diameter by 55-feet tall vessel or greater. The HP flare will also require a wind fence around each vessel.

Benefits – There will be no visible flame during the flaring process, direct radiation from the flame to the environment is eliminated, and the noise level should also be relatively low.

Drawbacks – The enclosed flare system will be highly visible during daylight hours (the vessels are large-diameter and nearly as tall as the elevated flare). They will require a large footprint; each of the three HP enclosed flares will have a diameter of 68 feet, after including the wind fence. The amount of construction required will be much higher for this option with corresponding environmental impact during the construction phase. The concept is not proven under arctic conditions.

2.3.7.4 Option FL-3: Ground Flare System

The ground flare system is a series of burners mounted at grade, surrounded by a radiation fence or installed in a gravel pit to block the surrounding area from direct flame radiation. This option will require the largest footprint of all the options. The area required for the HP flare alone is 235-feet long by 100-feet wide. The system will be 50-feet high. The multiple burners require an extensive piping and manifold network buried under a gravel pad to protect them from direct radiation.

Benefits – There will be no visible flame during the flaring process. Direct radiation from the flame to the environment is eliminated. The noise level should also be relatively low.

Drawbacks – The ground flare system will require an extensive gravel pad and complex piping system underneath it and a large area of tundra would be affected. The wide, long, high (over 50 x 200 x 100-feet) radiation fence would have a significant visual impact. The intense radiation from the ground flares can conduct sufficient heat into the pad and underlying permafrost to cause subsidence in the piping network. This can result in liquid HC (hydrocarbon) pockets in the piping, creating maintenance issues.

Summary and Conclusion

Elevated flare systems have been proven on the North Slope to reliably meet the flare system requirements with acceptable environmental impacts. The adverse visibility issues would be limited primarily to flaring events. The enclosed flare system is not proven for North Slope applications. Because of recent experience regarding the long-term degradation of the piping system and potential adverse environmental impact, ground-based systems are not considered suitable. Accordingly, an elevated flare system is the proposed action.

Since LP flaring occurs operationally on a more frequent basis, the lower the stack height with Option LP-1A, the less visible will be the flare and the more shielded would be the noise caused by flaring. If the LP flare were common with the HP flare in a single stack, the flaring would be more visible because the stack is higher. Option LP-1A is the proposed action because it would be less visible during the most common flaring events.

Table 2-7 summarizes the analysis of flare options.

TABLE 2-7: SUMMARY OF FLARE SYSTEM OPTIONS ANALYSIS

Field Development Options	Basis for Decision
FL-1A. Elevated flare system – Separate stack for LP and HP flare (Proposed Action)	• Elevated flares are a proven design and have been used extensively on the North Slope. • The more commonly used LP flare would be less visible because it is 40 feet off the ground and may possibly be somewhat shielded by structures. • Noise from the LP flare may be shielded by structures.
FL-1B. Elevated flare system – Single Stack for LP and HP flare	• Elevated flares are a proven design and have been used extensively on the North Slope. • Common HP and LP flares would be more visible for a greater distance. • Noise from the LP flare may not shielded by structures as in FL-1A.
FL-2. Enclosed flare system	• Enclosed flares design has not been used on the North Slope and reliability and environmental impacts are unknown.
FL-3. Ground flare system	• Some ground flare systems have caused permafrost thawing and subsidence. • Ground flare systems have encountered long-term maintenance and reliability issues.

2.4 ALTERNATIVES CONCLUSIONS

Compliance with NEPA and CEQ regulations for implementing NEPA require that an EIS analyze a reasonable range of alternatives that meets the purpose and need of the proposed action. The Proposed Action and alternatives should be presented in a comparative form that sharply defines the issues and provides a clear basis for choice among options by the decision-maker and the public. The reasonable range of alternatives includes a no action and preferred action alternative.

The purpose and need for the Project is to develop the Thomson Sand reservoir and initiate commercial hydrocarbon production by the end of 2014. As part of the component analysis and evaluation of potential alternatives to be considered for NEPA compliance, ExxonMobil reviewed available studies associated with Point Thomson and other North Slope developments. The alternatives considered are those that are consistent with the purpose and need of the Point Thomson Project, practicable in terms of efficient field development, and reduced environmental effects. Alternatives that would be considered practicable in terms of purpose and need, project design, construction and operations require:

- well pad locations that integrate current drilling, provide for efficient development of the reservoir, and reduce the need for additional gravel fill and new gravel footprint;
- export and gathering pipelines that can maintain pipeline integrity, allow visual inspection, allow for movement of terrestrial mammals, and provide flexibility and expandability for potential field expansion and gas sales; and

- module offloading facilities that meet construction and production schedules, and reduce potential environmental effects and requirements for dredging.

Certain component options are not considered practicable in terms of current and future field development, facility integrity, logistical risk, safety, and adverse environmental effects. These include:

- drilling and production pads located further inland from the coast;
- a buried export pipeline (offshore or onshore);
- gathering lines buried in the tundra or gravel roads;
- a project that relies on facilities at Badami that may not be available or that require substantial upgrades and are not situated for efficient field operation; and
- a solid fill module offloading dock that may be more effective in terms of cost and schedule but has greater adverse environmental effects.

Two alternative scenarios which have common components with the Proposed Action that might be considered during NEPA analysis were evaluated. These alternatives have tradeoffs with practicability and environmental effects and are not the Proposed Action:

- An alternative that eliminates gravel roads connecting the East and West Pads with the CP. The description, benefits, and drawbacks of this alternative are contained in Section 2.3.4.1.
- An alternative that locates the export pipeline further inland, between West Pad and the Badami pipeline connection. It should be noted that the proposed location of an alternative inland pipeline route would need to be determined in consultation with agencies and other parties, and needs to consider geotechnical, hydrological, wildlife, subsistence, and cost characteristics. The description, benefits, and drawbacks of this alternative are contained in Section 2.3.3.1.

3.0 AFFECTED ENVIRONMENT

3.1 PHYSICAL ENVIRONMENT

3.1.1 Meteorology and Air Quality

3.1.1.1 Meteorology

The proposed Point Thomson Project (hereinafter the Project) area exists within the Arctic climate zone. This region refers to the area in the northern hemisphere north of the Arctic Circle at a latitude of 66 degrees (°), 32 minutes that is above the northern limit of upright tree growth near the Beaufort Sea Coast (National Snow and Ice Data Center [NSIDC] 2009). The Arctic climate zone in the region of the affected environment includes both polar maritime (influenced by the Beaufort Sea) and continental (influenced by the North Slope and Brooks Range mountains) climate subtypes. Both subtypes contribute to the local meteorology of the affected environment.

Solar Radiation and Temperature

At the high latitudes of the Arctic climate zone, climate is affected by the drastic changes in duration and intensity of solar radiation throughout the year. In winter, direct solar radiation is nonexistent because the sun does not rise above the earth's horizon. Consequently, extreme low temperatures can occur with minimum winter temperatures of approximately -79 degrees Fahrenheit (°F) (-62 degrees Celsius [°C]) below zero. In summer, the high incident angle of the sun causes less absorption of solar radiation than in lower latitudes. The angle of incidence refers to the angle at which the sun's rays strike the Earth's surface. In addition, snow and ice cover present for most of the year in the Arctic climate zone contribute to high reflectivity, termed albedo, of solar radiation and absorption of solar radiation in summer is further minimized. These conditions contribute to low daily average summer temperatures of approximately (50°F) 10°C above zero. Diurnal temperature changes may be nearly nonexistent in winter because of a complete lack of incoming solar radiation and in summer because of constant daylight. Diurnal temperature changes are most pronounced during the equinoxes, when changes in diurnal solar radiation are maximized.

Wind

Winds in the Project area have been shown to be primarily influenced by the orographic effects of the Brooks Range. Orographic effects refer to the influence that mountains have on wind direction and speed. The area of the affected environment on the eastern North Slope lies in close proximity of the Brooks Range, and air flow will have a tendency to move around rather than over the Brooks Range. This effect leads to an increase in wind speed near the Brooks Range. Also, at locations near the Brooks Range, wind direction is observed to follow the longitudinal axis of the mountains.

Atmospheric Dispersion

Atmospheric dispersion is a complex process that is affected by wind speed, duration and direction of wind, temperature, atmospheric stability, and mixing depth of the atmosphere. Wind affects the horizontal motion in the atmosphere, whereas atmospheric stability refers to the vertical motion in the atmosphere. Stability is defined as the change in density of the atmosphere with altitude that is affected by the variation of temperature and humidity that occurs over the vertical profile. The stability of the atmosphere plays a direct role in the amount of turbulence present in the atmosphere. Greater turbulence will lead to greater atmospheric dispersion as better mixing of air pollutants into the atmosphere occurs. High winds contribute to greater mixing of air pollutants in the atmosphere that will generally improve dispersion.

Data for the Project show nearly consistent wind with relatively few calm periods (see Figures 3-1 through 3-4). These data demonstrate relative good mixing for atmospheric dispersion in the affected environment. Air modeling demonstrations that are representative of dispersion for the Project area have been completed in the affected environment, including the sensitive areas of the Alaska National Wildlife Refuge (hereinafter the Refuge) and the rural community of Kaktovik.

Sophisticated models such as U.S. Environmental Protection Agency (EPA's) AERMOD model use local meteorological data to predict the dispersion characteristics of a project's emissions released into the atmosphere. For example, modeling data for the Liberty Project near the Endicott Production Facility and projects associated with the Outer Continental Shelf (OCS) show that dispersion is good and, at distances greater than 6.21 miles (10 kilometers), impacts from pollutant emissions are typically negligible. Section 4.1.1 provides a discussion of the results of modeling demonstrations and the expected atmospheric dispersion of the affected environment.

Meteorological Monitoring

Data for similar climatic regions that represent the meteorology of the affected environment that includes the Project area and other resources, including the Refuge and Kaktovik, are available on the North Slope. From 2001–2006, data were collected at the Badami Development Facility, the Endicott Production Facility, and the Milne Point Production Facility (Table 3-1) as part of the Minerals Management Service (MMS) Beaufort Sea Meteorological Monitoring and Data Synthesis Project (HCG Inc. 2007). Data that may be representative of the affected environment are also available for the Deadhorse Airport for the same time period from the National Climatic Data Center (NCDC 2009).

In Figure 3-1 through 3-4, specific wind roses are provided for the Badami Development Project, the Endicott Production Facility, the Milne Point Production Facility, and the Deadhorse Airport, for 2001–2006, respectively. Wind roses are divided into four cardinal directions that show the frequency of winds displayed as spokes. The long axis of each spoke displays the direction for which the wind blows. The length of each spoke is proportional to the amount of time that wind blows from a particular direction. Wind speeds are denoted in a color scale that is used to determine the frequency of wind speeds for each directional spoke. These wind roses show that winds in the affected environment predominately occur in two directions following the axis of the Brooks Range, with dominant flows occurring from the northeast with minor components occurring from the southwest.

3.1.1.2 Air Quality

Federal and state air quality standards have been established to protect human health and welfare. Monitoring of air quality is conducted to measure the actual levels of selected pollutants and to designate regional air quality in areas of the state. These areas receive air quality classifications that establish limits on air pollution from projects to prevent further degradation of air quality in these areas.

Air Quality Standards

Projects that will have an impact on air quality must meet the primary National Ambient Air Quality Standards (NAAQS) and the Alaska Ambient Air Quality Standards (AAAQS) for nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particles of 10 micrometers or less in aerodynamic diameter (PM_{10}), particles less than 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$), carbon monoxide (CO), lead, and ozone (O_3). These standards are designed to protect the public from any known or anticipated adverse effects associated with the presence of such air pollutants in the ambient air. Annual average and 24-hour to hourly average air quality standards exist to protect the public from long-term and short-term risks that may be associated with exposure to these air pollutants.

In addition, the Alaska Department of Environmental Conservation (ADEC) has established classification areas of the state with increment limits for NO_2, SO_2, and PM_{10} to limit increases in air pollution for a project and limit the degradation of existing air quality of the region. Lower classification designates an area with more stringent increment limits. For example, Class I areas include areas of special interest such as national parks and wilderness areas. The nearest Class I area from the affected environment of the Project area is Denali National Park, located more than 497 miles (800 kilometers) to the southwest. The affected environment of the Project, including the North Slope, the Refuge, and the rural communities of Kaktovik and Nuiqsut, exists in a Class II area and that is unclassifiable or in attainment with all NAAQS and AAAQS. Slightly more air quality degradation is allowed in a Class II area than in a Class I area, but never to the point of causing a violation of a NAAQS or AAAQS. The unclassifiable distinction is given if sufficient monitoring data are not available to make a determination of air quality, even though the air in this area is likely in compliance with the NAAQS and AAAQS.

Air Quality Monitoring

Site-specific ambient air quality monitoring data are not available for the immediate area surrounding the Project. However, data that are representative of the Project have been collected for nearby areas in the affected environment. Ambient NO_2, SO_2, and CO data were collected for the Liberty Project Air Monitoring Program (LPAMP) located at the Endicott Production Facility from February 2007–January 2008. Ambient NO_2, SO_2, O_3, and PM_{10} data were collected at the Central Compressor Plant (CCP) as part of the Prudhoe Bay Ambient Air Monitoring Program (PBAAMP). Ambient NO_2, SO_2, O_3, and PM_{10} data were collected for calendar year 1999 at the Badami Development Project as part of the Alaska North Slope

Eastern Region (ANSER) Monitoring Program. Tables 3-2, 3-3, and 3-4 provide quarterly and annual summaries of the criteria pollutant concentrations and comparisons to the NAAQS/AAAQS measured at the LPAMP (HCG Inc. 2008), PBAAMP (ENSR 2008), and ANSER (ENSR 2000), respectively. The NO_2, SO_2, CO, PM_{10}, and O_3 pollutant data document good air quality in the affected environment and each pollutant concentration is in compliance with the respective NAAQS/AAAQS.

TABLE 3-1: METEOROLOGICAL DATA STATISTICS FOR 2001–2006

Parameter	Badami	Endicott	Milne Point	Deadhorse
Average Wind Speed (meters per second)	5.9	5.3	5.1	5.4
Maximum Wind Speed (meters per second)	35.5	30.6	33.8	25.2
Average Temperature (degrees Celsius)	-10.7	-10.4	-10.6	-10.8
Minimum Temperature (degrees Celsius)	-45.3	-42.2	-43.6	-46.2
Maximum Temperature (degrees Celsius)	26.1	19.1	21.9	27.2
Average Relative Humidity (percent)	85	86	86	84
Minimum Relative Humidity (percent)	30	39	31	6.0
Maximum Relative Humidity (percent)	100	100	100	100
Average Barometric Pressure (millibars)	1,015.6	1,014.6	1,016.8	1,012
Minimum Barometric Pressure (millibars)	976.0	974.6	975.8	971
Maximum Barometric Pressure (millibars)	1,056.0	1,055.6	1,056.8	1,053
Average Solar Radiation (watts per square meter)	103.9	100.5	95.4	NA
Maximum Solar Radiation (watts per square meter)	797	791	746	NA

Notes:
NA = Not Available

TABLE 3-2: AMBIENT AIR QUALITY STANDARDS AND BP EXPLORATION (ALASKA) LIBERTY PROJECT AMBIENT AIR MONITORING DATA, FEBRUARY 2007–JANUARY 2008

Pollutant	National and Alaska Ambient Air Quality Standards (NAAQS/AAAQS)		BP Exploration (Alaska) Liberty Project Ambient Air Monitoring–Pollutant Data (ppm)						Percent of NAAQS/ AAAQS
	Primary Standard	**Secondary Standard**	**Averaging Period**	**Quarter A**	**Quarter B**	**Quarter C**	**Quarter D**	**Annual**	
Nitrogen Dioxide (NO_2)	Annual Average 0.053 ppm (100 $\mu g/m^3$)	Same as Primary Standard	Quarterly and Annual Averages	0.017	0.001	0.001	0.006	0.006	11.4
			1st Highest 1-hour Average	0.449	0.064	0.054	0.248	0.449	-
			2nd Highest 1-hour Average	0.444	0.062	0.046	0.200	0.444	-
Carbon Monoxide (CO)	8-hour Average 9 ppm (10 mg/m^3)	None	Quarterly and Annual Averages	0.20	0.12	0.13	0.16	0.15	-
			1st Highest 8-hour Average	0.34	0.23	0.96	0.31	0.96	10.7
			2nd Highest 8-hour Average	0.30	0.23	0.94	0.31	0.94	10.4
	1-hour Average 35 ppm (40 mg/m^3)	None	1st Highest 1-hour Average	0.41	0.27	1.53	0.42	1.53	4.4
			2nd Highest 1-hour Average	0.41	0.25	1.17	0.42	1.17	3.3

Pollutant	National and Alaska Ambient Air Quality Standards (NAAQS/AAAQS)		BP Exploration (Alaska) Liberty Project Ambient Air Monitoring–Pollutant Data (ppm)						Percent of NAAQS/ AAAQS
	Primary Standard	Secondary Standard	Averaging Period	Quarter A	Quarter B	Quarter C	Quarter D	Annual	
Sulfur Dioxide (SO_2)	Annual Average 0.03 ppm (80 μg/m^3)	-	Quarterly and Annual Averages	0.001	0.001	0.001	0.001	0.001	3.3
			1st Highest 1-hour Average	0.019	0.003	0.005	0.010	0.019	-
			2nd Highest 1-hour Average	0.016	0.003	0.004	0.010	0.016	-
	24-hour Average 0.14 ppm (365 μg/m^3)	-	1st Highest 24-hour Average	0.005	0.001	0.002	0.003	0.005	3.6
			2nd Highest 24-hour Average	0.005	0.001	0.002	0.003	0.005	3.6
	-	3-hour Average 0.50 ppm (1,300 μg/m^3)	1st Highest 3-hour Average	0.016	0.003	0.004	0.009	0.016	3.2
			2nd Highest 3-hour Average	0.014	0.003	0.004	0.008	0.014	2.8

Notes:
AAAQS = Alaska Ambient Air Quality Standards
μg/m^3 = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
NAAQS = National Ambient Air Quality Standards
ppm = parts per million

TABLE 3-3: AMBIENT AIR QUALITY STANDARDS AND BP EXPLORATION (ALASKA) PRUDHOE BAY UNIT (CCP) AMBIENT AIR MONITORING DATA, JANUARY 2007–DECEMBER 2007

Pollutant	National and Alaska Ambient Air Quality Standards (NAAQS/AAAQS)		BP Exploration (Alaska) Prudhoe Bay Ambient Air Monitoring–Pollutant Data (ppm)						Percent of NAAQS/ AAAQS
	Primary Standard	**Secondary Standard**	**Averaging Period**	**Quarter A**	**Quarter B**	**Quarter C**	**Quarter D**	**Annual**	
Nitrogen Dioxide (NO_2)	Annual Average 0.053 ppm (100 μg/m^3)	Same as Primary Standard	Quarterly and Annual Averages	0.011	0.012	0.008	0.011	0.010	18.9
Ozone (O_3)	1-hour Average 0.117 ppm (235 μg/m3)	-	1st Highest 1-hour Average	0.046	0.043	0.035	0.040	0.046	39.3
Sulfur Dioxide (SO_2)	Annual Average 0.03 ppm (80 μg/m^3)	-	Quarterly and Annual Averages	0.000	0.001	0.000	0.002	0.001	3.3
	24-hour Average 0.14 ppm (365 μg/m^3)	-	1st Highest 24-hour Average	0.003	0.006	0.003	0.009	0.009	6.4
	-	3-hour Average 0.50 ppm (1,300 μg/m^3)	1st Highest 3-hour Average	0.005	0.007	0.008	0.011	0.011	2.2
Particulate Matter less than 10 Microns/ Micrometers (PM_{10})	Annual Average 50 μg/m^3	-	Quarterly and Annual Averages	5.1	4.7	8.6	9.5	7.0	14.0
	24-hour Average 150 μg/m^3	-	Maximum 24-hour Average	24.9	18.0	42.0	52.8	52.8	35.2

Notes:
AAAQS = Alaska Ambient Air Quality Standards
ANSER = Alaska North Slope Eastern Region
CCP = Central Compressor Plant
μg/m^3 = micrograms per cubic meter
NAAQS = National Ambient Air Quality Standards
ppm = parts per million

TABLE 3-4: AMBIENT AIR QUALITY STANDARDS AND BP EXPLORATION (ALASKA) ANSER AMBIENT AIR MONITORING DATA, CALENDAR YEAR 1999

Pollutant	National and Alaska Ambient Air Quality Standards (NAAQS/AAAQS)		BP Exploration (Alaska) ANSER Ambient Air Monitoring–Pollutant Data (μg/m³)						Percent of NAAQS/ AAAQS
	Primary Standard	Secondary Standard	Averaging Period	Quarter A	Quarter B	Quarter C	Quarter D	Annual	
Nitrogen Dioxide (NO_2)	Annual Average 0.053 ppm (100 μg/m³)	Same as Primary Standard	Quarterly and Annual Averages	6.3	1.9	1.9	1.9	3.8	3.8
Ozone (O_3)	1-hour Average 0.117 ppm (235 μg/m³)	-	1st Highest 1-hour Average	94.1	92.1	90.2	88.2	94.1	40.0
			2nd Highest 1-hour Average	94.1	92.1	78.4	82.3	94.1	40.0
Sulfur Dioxide (SO_2)	Annual Average 0.03 ppm (80 μg/m³)	-	Quarterly and Annual Averages	2.6	2.6	2.6	2.6	2.6	3.3
	24-Hour Average 0.14 ppm (365 μg/m³)	-	1st Highest 24-Hour Average	15.7	5.2	2.6	5.2	15.7	4.3
			2nd Highest 24-Hour Average	15.7	5.2	2.6	5.2	15.7	4.3
	-	3-Hour Average 0.50 ppm (1,300 μg/m³)	1st Highest 3-Hour Average	18.3	7.9	5.2	7.9	18.3	1.4
			2nd Highest 3-Hour Average	18.3	7.9	5.2	7.9	18.3	1.4
Particulate Matter less than 10 Microns/ Micrometers (PM_{10})	Annual Average 50 μg/m³	-	Quarterly and Annual Averages	2.6	1.4	2.7	0.8	1.9	3.8
	24-hour Average 150 μg/m³	-	Maximum 24-hour Average	9.5	4.9	12.4	4.8	12.4	8.2

Notes:
AAAQS = Alaska Ambient Air Quality Standards
ANSER = Alaska North Slope Eastern Region
CCP = Central Compressor Plant
μg/m³ = micrograms per cubic meter
NAAQS = National Ambient Air Quality Standards
ppm = parts per million

3.1.2 Geology and Geomorphology

3.1.2.1 Physiography and Stratigraphy

The entire Project is located within the Arctic Coastal Plain (ACP) physiographic province. This province is characterized by a smooth plain rising imperceptibly from the Arctic Ocean to a maximum elevation of approximately 600 feet above mean sea level (MSL) at its southern margin, roughly 40 miles inland in the vicinity of Point Thomson (Wahrhaftig 1960). The coastline makes little break in the profile of the coastal plain and shelf, and the shore is generally only 2–10 feet above the ocean. The coastal plain has a very low gradient and thus is very poorly drained. It is crossed by rivers originating in the uplands to the south.

The area is typified by numerous longitudinal thaw lakes oriented N 15 degrees (°) W from 3–20 feet in depth and generally oval or somewhat rectangular in shape. The coastal zone is located within 2–3 miles of the coastline and attains elevations of up to 20–30 feet above MSL. A poorly defined terrace face marks the transition from the coastal zone to the relatively higher, better-drained inland zone.

The entire land area is underlain by permafrost at least 1,000 feet thick. The permafrost table (base of zone of summer thaw) typically occurs 1–4 feet below the surface. A network of ice-wedge polygons covers the coastal plain; these are integrated patterns in the drained lake basins and in irregular hexagonal patterns elsewhere (Wahrhaftig 1960).

The Project area is situated on the ancient Canning River Fan, a complex of unconsolidated Quaternary (last two million years) sediments that forms a symmetrical convex-northward arc along the Beaufort Sea coast. This region is underlain at depth by Cenozoic, Mesozoic, and Paleozoic sedimentary rocks, some of which are oil-bearing. A geologic time scale is shown in Figure 3-5 and a geologic cross section for the central North Slope is shown in Figure 3-6. The crest of the Barrow Arch, a deep structural ridge of the pre-Mississippian Epoch, associated with oil and gas deposits, underlies the northern margin of the Canning River Fan at a depth of approximately 13,000 feet (Mull and Adams 1989).

The origin of the Canning River Fan is approximately 25 miles inland from the coast, where the trend of the Canning River turns from northwesterly to northeasterly. Exposure of the fan along the coast is typically less than 3 feet (1 meter) high, except where originally higher areas have not been dissected by flow. These areas typically stand several feet above sea level and expose lake-deposited silt, sand, and organic material overlying wind-deposited sand. The eastern part of the fan is currently active, with the Canning River and associated alluvial terraces covering approximately one-third of the fan surface. The central part of the fan is inactive, except for drainage that originates on the fan surface, and consists of sandy-gravel outwash (Canning Gravel) covered with a thin veneer of fluvial and eolian sand. The western part of the fan is sandy-gravel outwash covered with eolian sand that was deposited as subtle southwest-trending longitudinal dunes presumably when the central part of the fan was active and free of vegetation. Thaw lakes with long axes parallel to the trend of the dunes are present between the dunes.

The Canning River Fan extends into the submarine environment as a delta, and deposition of the fan has been more or less continuous through at least several seawater advances and retreats because of changes in sea levels (Wolf et al. 1985). Six late Cenozoic seawater advances have been well defined and correlated across the Coastal Plain (Carter et al. 1986a). Because the origin of the fan is nearly coincident with the northernmost limit of recognizable glacial till, deposition of the fan can probably be extended back at least to the onset of presumed early Pleistocene glaciation in the Canning River drainage. Wind-deposited or lake-deposited sediments, or both, which overlie Flaxman mud near the coast and outwash inland of the coast, are present on topographically high areas along the seaward margin of the fan and on Flaxman Island and the adjacent topographically high area that includes Bullen Point (Rawlinson 1990).

3.1.2.2 Seismicity and Faults

Although the North Slope of Alaska is overall generally considered to be an area of relatively low historical earthquake activity, there is some historical seismicity that generally occurs in the Brooks Range approximately 30 miles to the south and southwest, and there is a concentration of seismicity offshore in Camden Bay approximately 30 miles northeast (U.S. Geological Survey [USGS] 2009; Riehle et al. 1996; Combellick 1994; Page et al. 1991; Yokel and Bea 1986; Grantz et al. 1983). The historical earthquakes within the Brooks Range have had magnitudes (M) generally less than about M 3.5, with the largest being moment magnitude (M_W) 5.5 (USGS 2009). The concentration of earthquakes that have occurred offshore in Camden Bay, the largest of which was apparently M 5.3 (Combellick 1994), appears to be associated with mapped late Pleistocene and Holocene faults in the offshore area (Pflaker et al. 1994; Grantz et al. 1983).

The Project area lies north of the seismicity in the Brooks Range and generally west and southwest of the concentration of historical seismicity offshore in Camden Bay. Most historical seismicity in the area is shallow (less than 20 miles deep), which would suggest near-surface faulting, but no active faults are recognized at the surface (Combellick 1994). Grantz et al. (1983), however, map the northeast-striking, right-lateral displacement Canning River Displacement Zone along the Canning River Valley which is located east and southeast of the Project area.

Probabilistic seismic hazard mapping for Alaska (Wesson et al. 2007) indicates that the 475-year return period (10 percent probability of exceedance in 50 years) peak ground acceleration (PGA) is generally less than about 0.10 g (g = gravity, 32.2 feet per second squared) for the Project area. The 2,475-year return period (2 percent probability of exceedance in 50 years) PGA ranges from about 0.13–0.22 g (Wesson et al. 2007). For comparison, ground acceleration in Anchorage during the 27 March 1964 earthquake, the second-largest earthquake ever recorded, was estimated at 0.16 g.

3.1.2.3 Sand and Gravel Resources

The Project area is located on the western portion of the Canning River alluvial fan. Considerable sand and gravel resources deposited during the Quaternary Period (last two million years) underlie this area. The geology of the Project area is characterized by alluvial deposits on a very broad fan composed of silt, sand, and gravel that directly underlie the surficial organics. This suggests that sand and gravel resources are nearly limitless, once the surficial silt and organics are removed.

Geotechnical investigations conducted by Exxon Mobil Corporation (hereinafter ExxonMobil) have identified sufficient sand and gravel resources at a 60-acre gravel mine site to meet the needs of the Project. The site is centrally located to the Project, situated on slightly elevated terrain approximately 2 miles south of the coast and adjacent to the proposed airstrip. Gravel from this source will be used to construct approximately 12 miles of roads, six pads, and a new 5,600-foot-long airstrip, plus a stockpile of approximately 200,000 cubic yards (cy) for future maintenance. It is anticipated that approximately 3.4 million cy of material will be excavated from the proposed mine site. More than half of this total will be sand and gravel, while the remainder will be overburden. The overburden will be segregated into inorganic and organic stockpiles on seasonal ice pads (ExxonMobil 2009a).

Quarry rock for use as armor stone or riprap is not available within the Project area, as there are no bedrock outcrops. The nearest opportunity for quarry rock is from bedrock outcrops located more than 40 miles to the south.

3.1.2.4 Paleontological Resources

Paleontological resources are any physical evidence of past life, including fossilized remains, imprints, and traces of plants and animals. These resources are protected by federal and state acts, including the Antiquities Act of 1906, Federal and Land Policy and Management Act of 1998, Archaeological Resources Protection Act of 1979, and the Alaska Historic Preservation Act.

There are no particularly unique paleontological resources documented in the Project area. The bedrock underlying the Project area consists of thousands of feet of fossil-bearing sedimentary strata. These sedimentary rocks are overlain by fossil-bearing unconsolidated fluvial and eolian deposits. Fossils range from single-celled organisms to large vertebrates. Marine invertebrate fossils include bryozoans, brachiopods, pelecypods, gastropods, ostracods, crinoids, trilobites, belemnites, ammonites, and coral. Vertebrate fossils from fish in Middle Devonian rocks have been found on the North Slope to the west of the Project area. Marine plants also occur in these sedimentary rocks. Marine and terrestrial mammals such as otter, seal, whale, mammoth, moose, caribou, muskox, bison, camel, horse, and lion, as well as birds have been found in Quaternary deposits on the North Slope (Bureau of Land Management [BLM] 2002).

Invertebrate fossils from the Quaternary Period have been found on the barrier islands and on the coast in several locations in the Project area (Alaska Paleontological Database 2009).

3.1.2.5 Permafrost and Ground Temperatures

Permafrost is rock or soil, or both, that has natural temperatures that are consistently less than 32°F (0°C) for two years or more (Péwé 1982). The Arctic coastal maritime climate maintains permafrost, which is essential to development of ice wedges and ice-wedge polygons, thaw lakes, pingos, and thaw streams. Ice wedges are masses of ice that taper downward and develop by water or snow repeatedly filling thermal-contraction cracks and subsequently freezing or refreezing. Ice wedges are typically linked in polygonal forms (Lachenbruch 1962). Permafrost and seasonal freezing and thawing are conducive to frost processes that develop frost hills, peat rings, hummocks, and reticulate ground.

The permafrost on Alaska's North Slope is relatively cold (less than 20°F) (<-7°C), continuous, and typically encountered within a couple feet of the ground surface (Brown 1997). The permafrost is up to 2,000 feet thick, while the active layer is generally less than 1.5 feet, depending largely on soil texture. Unfrozen zones are shallow and usually limited to deep river channels and the deeper lakes (Ferrians 1965; Rawlinson 1993). Permafrost formed beneath the Beaufort Sea during the peak of the last Wisconsin glaciation, when the continental shelf was exposed to about a minus-300 foot isobath, about 110 miles north of the present coast (Rawlinson 1993).

Massive ground ice is widespread and occurs as vertical ice wedges, films, lenses, pore-fillings, and in other small, segregated masses. Most basin floors display the polygonal pattern of cellular ice-wedge networks. The polygons are bordered by sod dikes and, in the more poorly-drained areas, they typically have shallow saturated depressions in the center. The sod dikes overlie ice wedges. Shallow troughs along the crests of the dikes indicate actively growing ice wedges (Brown and Kreig 1983). Surficial soils typically consist of several feet of ice-rich organic silt overlying coarse sands and gravels. Ice wedges are the most sensitive to disturbance because, once disturbed, the ice can rapidly melt, causing significant settlement.

Pingos are ice-cored conical mounds that grow and persist in areas where moisture-rich lacustrine sediments are exposed to freezing temperatures. The substrate must be permeable and thick enough that the thawed basin extends into permafrost. Pore water is expelled from below the freezing front as permafrost aggrades into the thaw bulb and freezes at the front, forming an ice core (Brown and Kreig 1983).

3.1.2.6 Geomorphic Processes

The surficial soils within the Project area have been deposited predominantly by streams originating to the south. Permafrost is continuous in the region, and the distribution and amount of ice in the permafrost greatly affects the surface morphology. Wind-oriented thaw lakes dominate the landscape in the coastal zone. The thaw-lake basins originate in areas of restricted drainage, where shallow ponding results in a warmer surface temperature that causes the underlying ground ice to thaw, resulting in subsidence. Most of the ponds and lakes are relatively shallow.

The thaw lakes are considered dynamic and impermanent, and often go through a cycle of development, expansion, drainage, and revegetation. Ice tends to be concentrated in the top few meters of the permafrost (Sellman et al. 1975). Of several types of ice that occur in the near-surface sediments, segregated ice and ice wedges represent as much as 85 percent of the ground by volume, with the former contributing a much greater amount (75 percent) than the ice wedges (Brown 1967). Natural and human-induced differential thawing of this near-surface ice generally results in uneven lowering of the ground surface, which may lead to ponding of water or preferential erosion, or both (Rawlinson 1993).

3.1.2.7 Contaminated Sites

Various State of Alaska and federal electronic databases were searched for contaminated site information in the Project area. This search area encompassed a rectangular area that included the terrain between the Badami Development and the Canning River and extended more than 15 miles inland from the coast. The entire ADEC Contaminated Sites (CS) database was downloaded and sorted by maximum and minimum latitudes and longitudes, and then by site name or other information presented in the database for a particular listing. The state databases included the Spills Reports and CS databases (ADEC 2009a, 2009b).

The spills database listed 10 petroleum spills and one paint spill. These spill sites have been closed. The CS database was sorted by the search area, reducing it to 14 contaminated site listings. Of these sites, two at Bullen Point and one at the North Staines River No. 1 Gravel Pad are still open. A summary of the state database search results is presented in Table 3-5.

The EPA database was searched for clean-up sites that could be listed under various regulatory programs. No active contaminated or other sites were found in the federal database for the Project area (EPA 2009a). The federal database search criteria and clean-up programs searched and/or status for clean-ups is listed in Table 3-6.

3.1.2.8 Disturbed Areas

There are several areas within the Project area that have been previously disturbed. The Bullen Point Air Force Station Radar Site was staffed from 1953–1971 and is now operated as an unstaffed site. It includes a large pad, airstrip, landfill, and other infrastructure. Several other pads and material sites have been constructed by various companies for oil and gas exploration.

TABLE 3-5: SPILL REPORT SUMMARY

Date/Time	Spill Name	Address	Substance	Volume (Gallons)	Cleanup Status
Spill Reports Database Search Results					
8/3/1998	ExxonMobil Flaxman Island	no address	Diesel	250	closed
4/21/2001 18:00	Point Thomson Flaxman Island	Point Thomson Flaxman Island	Diesel	10	closed
1/8/2009 19:28	no name	Point Thomson Unit #3 Drill Pad	Diesel	284	closed
2/25/2009 14:10	Nanuq, spill on ice road near Point Thomson	Point Thomson Unit #3 Drill Pad	Diesel	0.5	closed
3/10/2009 21:30	no name	Point Thomson Unit #3 Drill Pad	Diesel	1	closed
3/29/2009 9:30	no name	Point Thomson Unit #3 Drill Pad	Engine Lube Oil	0.5	closed
4/16/2009 16:30	ExxonMobil Point Thomson Ice Rd	Point Thomson Unit #3 Drill Pad	Engine Lube Oil	0.5	closed
4/20/2009 10:00	no name	Point Thomson Unit #3 Drill Pad	Hydraulic Oil	1	closed
5/1/2009 6:45	ExxonMobil Paint Spill	Point Thomson Unit #3 Drill Pad	Other	0.75	closed
7/4/2009 3:00	no name	Point Thomson Unit #3 Drill Pad	Hydraulic Oil	0.25	closed
7/24/2009 14:00	Point Thomson Central Pad	Off Pioneer Ice Road on Pad, 3.5 miles	Hydraulic Oil	0.6	closed
Contaminated Sites Database Search Results					
8/28/1978	Exxon Point Thomson Exploration Unit 1	Point Thomson 2.5 miles southwest of Flaxman Island	Diesel	Unknown	closed

Notes:
Contaminated Sites Database Reference: http://.dec.state.ak.us/spar/csp/search
Spills Sites Database Reference: http://.dec.state.ak.us/spar/perp/search

TABLE 3-6: FEDERAL DATABASE SEARCH SUMMARY

Search Area Criteria	
• Decimal Degree Format: Latitude: 70.185792 Longitude: -146.32470 • Search Radius: 15 miles (largest radius allowed by program)	
Cleanup Program(s) Searched and/or Status for All Clean-ups	
■ Brownfields Properties • Assessment Grants • Assessment Pilots • Clean-up Grants • RLF Grants • RLF Pilots • State and Tribal 128(a) Grants • Targeted Brownfields Assessments ■ Federal Facilities • BRAC • RCRA • Superfund (CERCLA)	■ RCRA Corrective Action • Current Corrective Action • Remedy Selected • Construction Complete • Remedy Action Complete • Remedy Not Yet Selected ■ Superfund • Proposed • Final • Deleted ■ Recovery • Brownfields • Superfund

Notes:
BRAC = Base Realignment and Closure
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
RCRA = Resource Conservation and Recovery Act
RLF = Revolving Loan Fund

3.1.3 Fresh Water Resources and Hydrology

3.1.3.1 Hydrology

Surface Water

Rivers and Streams

The runoff characteristics of watersheds within the Project area are influenced by climate, physiography, surficial geology, and permafrost. A number of rivers and streams cross the proposed pipeline and road alignments associated with the Project (Figure 3-7). All of these rivers and streams appear to have their headwaters in either the Arctic Foothills or the ACP physiographic provinces, with most headwaters in the ACP. Because there are some general characteristics of the rivers and streams that can be inferred from the physiographic provinces through which the rivers and streams flow, a short description of the physiographic provinces and the general characteristics of river reaches within those provinces is presented.

The ACP begins a few feet above the shoreline of the Beaufort Sea and extends to the Arctic Foothills, which can be as high as 600 feet above MSL (Hydrocon 1982). Stream reaches within the ACP generally have lower gradients and velocities than those found in the Foothills or the Brooks Range provinces. Streams originating on the ACP are often the first to freeze in the fall, and are often dry or nearly dry at freeze-up. These streams are usually the last to break up in the spring, with break-up timing significantly influenced by local weather patterns. Because the ice in these streams tends to freeze to the streambed, and because thaw bulbs probably do not exist below most of these streams, they tend to have few ice floes during break-up.

The Arctic Foothills province is between the ACP and the Brooks Range provinces. The Arctic Foothills generally consist of low, rolling hills with intermediate plateaus and tundra plains. Stream reaches within the Arctic Foothills are generally steeper than those in the ACP and generally have higher velocities. Streams originating in the Arctic Foothills tend to break up earlier and freeze up later than those in the ACP.

The rivers and streams crossed by the proposed pipelines and road routes associated with the Project have drainage areas that vary in size from less than 1 square mile to more than 90 square miles (Michael Baker Jr., Inc. 1998; PND 2009a). Several of the watersheds lack clearly defined boundaries or drainage channels, whereas others contain well-defined stream channels. The median size of the drainage basins crossed by the proposed pipelines and road routes is probably less than 6 square miles. Most of these streams are small and often consist of a tundra-lined swale. Some of the streams are beaded, which means that they consist of a series of small pools interconnected by short, narrow stream segments. Some of the streams have incised channels with gravel beds. The streams that are not simply tundra swales usually have a gravel streambed, and gravel is often found in the bottom of the small pools in the beaded streams. Hydrologic data were collected for some of the rivers and streams in 1983 (Dames & Moore), 1998 (Michael Baker Jr., Inc.), 2003a (URS), and 2009 (PND), and are summarized in Tables 3-7 and 3-8. Estimates of the magnitude of the flood peak discharge anticipated to occur on average every 2, 5, 10, 25, 50, 100, 200, and 500 years are presented in Table 3-9 for selected proposed pipeline and road crossing routes associated with the Project.

The major rivers that border the Project area are: the Canning and Staines rivers to the east, and the Shaviovik River to the West. The Staines River is a distributary of the Canning River. The Canning River has its headwaters in the Brooks Range province and has a drainage area of approximately 2,200 square miles (ExxonMobil 2003). The Shaviovik River also has its headwaters in the Brook Range and has a drainage area of approximately 1,600 square miles.

TABLE 3-7: SUMMARY OF AVAILABLE STREAM FLOW DATA COLLECTED WITHIN ONE MILE OF THE PROPOSED PROJECT PIPELINE OR ROAD ALIGNMENTS

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
West Badami Creek	P2009-01	52.1	2009	June	6	222.3	2	40	2.9		PND 2009
	25		2003	June	3			70			URS 2003a
	PLX01		1998	May	29		< 2[3]	459[3]		8.6[3]	MBJ 1998
Middle Badami Creek	P2009-02	23.1									PND 2009
	P2009-02		2009	June	8	232	2.8	54	1.5		PND 2009
	24		2003	June	5			220			URS 2003a
	24		2003	June	6			180			URS 2003a
	24		2003	June	8			70			URS 2003a
	PLX02		1998	June	29		< 2[3]	358[3]		10.9[3]	MBJ 1998
East Badami Creek	P2009-03	95.8	2009	June	10	174	1.4	93		2	PND 2009
	23		2003	June	5	3,480	4.7	448	1.7	2.6	URS 2003a
	23		2003	June	5	4,200[4]					URS 2003a
	23		2003	June	6	2,330	3.9	417	1.4	2.8	URS 2003a
	23		2003	June	7	1,530	3.8	213	1.9	3.4	URS 2003a
	23		2003	June	8	909	2.8	207	1.6	2.7	URS 2003a
	23		2003	July	1	15	0.7	44	0.5	1	URS 2003a
	PLX03		1998	May	29		> 5[3]	276[3]		6[3]	MBJ 1998
	PLX03		1998	June	1	596	1.94	143	2.1	3.2	MBJ 1998
	MP 31.8		1982	July		2					DM 1983
	MP 31.8		1983	July	15	2.46					DM 1983
	MP 31.8		1983	Aug	22	0.81					DM 1983
	MP 31.8		1983	Sept	15	23.4					DM 1983

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
"O" Creek	P2009-04	5.6	2009	June	10	21	1	18		2.5	PND 2009
	21		2003	June	5			430			URS 2003a
	21		2003	June	8			300			URS 2003a
	O1		2002	Aug	7	0.5-1 (est.)					Winters 2004
	PLX04		1998	May	29		< 2.5[3]	200[3]		4.0[3]	MBJ 1998
	PLX04		1998	May	30	225	1.63	132	1	2.7	MBJ 1998
"N" Creek	P2009-05	17.8	2009	June	8	194	2.4	61		2.5	PND 2009
	20		2003	June	5	1,100[4]					URS 2003a
	20		2003	June	6	734	3.2	159.5	1.5	2.6	URS 2003a
	20		2003	June	7	390	3.1	96	1.3	2.3	URS 2003a
	20		2003	June	8	230	2.1	72	1.5	3.7	URS 2003a
	20		2003	June	30	0.5	0.27	5.5	0.3	0.5	URS 2003a
	PLX06		1998	May	29			335[3]		5.8[3]	MBJ 1998
	PLX06		1998	June	1	207	2.47	56	1.49	3.4	MBJ 1998
"M" Creek	P2009-06	4.2	2009	June	8	55	2.1	24		3.2	PND 2009
	19		2003	June	5			770[6]			URS 2003a
	19		2003	June	5	76.6[6]	2.41	21	1.5	2.6	URS 2003a
	19		2003	June	6			>100			URS 2003a
	19		2003	June	6	135	2.18	24	2.6	3.4	URS 2003a
	19		2003	June	7	140[4]					URS 2003a
	19		2003	June	8			60			URS 2003a
	19		2003	June	8	86.8	1.37	25	2.5	3.1	URS 2003a
	19		2003	June	30	0.6	0.08	11.5	0.7	1.3	URS 2003a
	19		2003	July	2	0.4	0.1	5.2	0.7	1	URS 2003a
	PLX07		1998	May	29			168[3]		5.2[3]	MBJ 1998
	PLX07		1998	June	1	82.3	2	52	0.79	1.3	MBJ 1998

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
No Name Drainage 1	PLX08	1.35	1998								MBJ 1998
	PLX08		1998	May	29			80[3]		1.6[3]	MBJ 1998
	PLX08		1998	June	1	13	0.93	23	0.61	0.9	MBJ 1998
"L" Creek	P2009-07	39.1	2009	[5]	[5]	296	2.6	60		1.7	PND 2009
	18		2003	June	5			380			URS 2003a
	18		2003	June	8			90			URS 2003a
	L1		2002	Aug	7	1 (est.)					Winters 2004
	PLX09		1998	May	29		> 5[3]	290[3]		5.3[3]	MBJ 1998
	PLX09		1998	May	30	~600	~3.9	~97	~1.6	2.3	MBJ 1998
	MP 38.0		1983	July	15	0.3					DM 1983
	MP 38.0		1983	Aug	22	0.0					DM 1983
	MP 38.0		1983	Sept	15	4.2					DM 1983
"K" Creek	P2009-08	18.7	2009	June	8	184	1.6	63		2.2	PND 2009
	17		2003	June	8			70			URS 2003a
	PLX10		1998	May	29		> 3[3]	~440[3]		5.2[3]	MBJ 1998
	PLX10		1998	June	1	176	2.3	73	1.1	2.2	MBJ 1998
"J" Creek	P2009-09	2.2	2009	[5]	[5]	49	2.1	22		1.9	PND 2009
	16		2003	June	8			50			URS 2003a
	J1		2002	Aug	7	1-2 (est.)					Winters 2004
	PLX11		1998	May	29		> 1[3]	~304[3]		4.2[3]	MBJ 1998
	PLX11		1998	June	1	65	1.0	64	1.0	3	MBJ 1998
"I" Creek	P2009-10	22.6	2009	[5]	[5]	175	1.6	83		3	PND 2009
	15		2003	June	6			>1,000			URS 2003a
	15		2003	June	8			140			URS 2003a
	PLX12		1998	May	29		> 3[3]	202[3]		5.9[3]	MBJ 1998
	PLX12		1998	June	1	245	1.7	93	1.5	3	MBJ 1998

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
"H" Creek	H1		2002	Aug	6	0.5 (est.)					Winters 2004
"G" Creek	P2009-11	16.7	2009	[5]	[5]	31	1.5	22		2.5	PND 2009
	13		2003	June	6			110			URS 2003a
			2003	June	8			50			URS 2003a
	G1		2002	Aug	3	2 (est.)					Winters 2004
	PLX15		1998	May	29		> 3.5[3]	243[3]		6.6[3]	MBJ 1998
	PLX15		1998	June	3	49	1.1	27	1.7	3.5	MBJ 1998
"F" Creek	P2009-12	18.4	2009	[5]	[5]	48	1.5	25		2.3	PND 2009
	12		2003	June	6			80			URS 2003a
	12		2003	June	8			50			URS 2003a
	F2		2002	Aug	3	1 (est.)					Winters 2004
	PLX16		1998	May	29		> 5.0[3]	101[3]		3.2[3]	MBJ 1998
	PLX16		1998	May	30	254	~ 4.1	38		~ 2.6	MBJ 1998
Creek 18a	R2009-01	0.6	2009	[5]	[5]	33	1.3	15		1.7	PND 2009
"E" Creek	R2009-02	9.6	2009	June	6	193	1.9	53		3	PND 2009
"D" Creek	R2009-03	8.1	2009	June	13	171	1.8	87		1.6	PND 2009
"C" Creek	P2009-16	1.8									PND 2009
	1		2003	June	6			165			URS 2003a
	1		2003	June	8			90			URS 2003a
	1		2003	June	11						URS 2003a
	PLX22		1998								MBJ 1998
	PLX22		1998	May	29		< 2.5[3]	~ 204[3]		5.5[3]	MBJ 1998
	PLX22		1998	May	31	117	1.36	78	1.11	2.7	MBJ 1998
	R2009-04	1.5	2009	June	13	171	2.1	46		3	PND 2009

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
Creek 23	P2009-17	0.5	2009	[5]	[5]	7.5	0.6	12		1.5	PND 2009
	PLX23		1998	May	29		< 2.5[3]	60[3]		2.0[3]	MBJ 1998
"B" Creek	P2009-18	2									PND 2009
	27		2003	June	3			205			URS 2003a
	27		2003	June	4	55.4	2.9	54	0.4	1.4	URS 2003a
	27		2003	June	5	170	0.49	333	1.1	1.9	URS 2003a
	27		2003	June	6–7	1,500[4]					URS 2003a
	27		2003	June	7	324	3.52	58	1.6	2.7	URS 2003a
	27		2003	June	8	162	2.45	33	2.0	3.0	URS 2003a
	27		2003	June	9	89	1.7	36	1.5	2.7	URS 2003a
	27		2003	June	10	67	1.5	36	1.3	2.4	URS 2003a
	27		2003	June	11	49	1.4	35	1.0	2.2	URS 2003a
	27		2003	June	12	34	1.2	36	0.8	1.9	URS 2003a
	27		2003	June	13	28	1.1	35	0.7	1.8	URS 2003a
	27		2003	July	1	0.4	0.1	10	0.6	0.9	URS 2003a
	27		2003	July	2	0.8	0.4	7	0.4	0.6	URS 2003a
	27		2003	----	----						URS 2003a
	PLX24		1998	May	29		< 3.0[3]	202[3]		7.8[3]	MBJ 1998
	PLX24		1998	May	31	271	2.9	74	1.3	2.7	MBJ 1998
	R2009-06	0.6	2009	June	13	178	2.1	46		3	PND 2009
	R2009-07	0.2	2009	June	13	27	2.9	12		1.5	PND 2009
"S" Creek	P2009-19	7.7	2009	June	9	12	1.6	17		1.9	PND 2009
	S1		2003	July	9	0					Winters 2004
	PLX26		1998	May	29		< 2.0[3]	260[3]		3.9[3]	MBJ 1998

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Date Data Collected			Stream Flow Measurements					Reference
			Year	Month	Day	Discharge (cfs)	Average Velocity (fps)	Water Surface Width (ft)	Average Flow Depth (ft)	Max Flow Depth (ft)	
"R" Creek	P2009-20	0.7	2009	June	9	37	2.1	18		1.9	PND 2009
	R1		2003	July	9	1 (est.)					Winters 2004
	PLX27		1998	May	30		< 3.0[3]	101[3]		2.8[3]	MBJ 1998
	PLX27		1998	May	31	81	1.7	37	1.3	2.4	MBJ 1998
	R2009-09	2.4									PND 2009

Notes:
Based on a visual inspection of the maps contained in the Dames & Moore (1983) and Hydrocon (1982) documents, the Dames & Moore monitoring sites (1983) on East Badami Creek and "L" Creek appear to be within 1 mile of the 2009 proposed pipeline alignment (PND 2009a).

1 Based on a visual inspection of the maps contained in the referenced documents, the pipeline alignment monitored by URS (2003a) appears to be approximately the same pipeline alignment monitored by PND (2009a).

2 Based on a visual inspection of the maps contained in the referenced documents, the pipeline alignment monitored by Michael Baker Jr., Inc. (1998) is usually within one-half mile of the pipeline alignment monitored by PND (2009a). It is often closer to the coast.

3 Measurement was made at the spring peak stage.

4 Estimate of spring peak discharge based on extrapolation from other measurements.

5 The exact date of the measurement was not provided, but the date must have been between May 27th and June 13th, the period during which field measurements were made.

6 Water surface width greatly affected by downstream snow blockage.

cfs = cubic feet per second
fps = feet per second
ft = feet
sq. mi. = square mile

TABLE 3-8: SUMMARY OF AVAILABLE STREAM WIDTH AND BANKFULL DATA COLLECTED WITHIN ONE MILE OF THE PROPOSED PROJECT PIPELINE OR ROAD ALIGNMENTS

Stream Name	Site Location[1,2]	Approximate Drainage Area (sq. mi.)	Stream Width (ft)				Bankfull		Reference
			Gravel in Channel	Ordinary High Water [3]	Top of Low Flow Banks [4]	Flood-plain Breaks [5]	Bankfull	Max Depth (ft)	
West Badami Creek	P2009-01	52.1							PND 2009
	25		25	25	25	50			URS 2003a
	PLX01		30–56				58–91	3.6–4.8	MBJ 1998
Middle Badami Creek	P2009-02	23.1							PND 2009
	24		2	2	2	-----			URS 2003a
	PLX02		4–13				45–56	3.6–4.2	MBJ 1998
East Badami Creek	P2009-03	95.8							PND 2009
	23		270	270	270	520			URS 2003a
	PLX03		143–301				220–330	3.0–5.2	MBJ 1998
"O" Creek	P2009-04	5.6							PND 2009
	21 - East		4	4	25	300[16]			URS 2003a
	21 - West		0	9	28				URS 2003a
	PLX04		14–36				41–58	1.8–3.4	MBJ 1998
"N" Creek	P2009-05	17.8							PND 2009
	20		14	14	14	200			URS 2003a
	PLX06		12–24				56–66	3.2–3.7	MBJ 1998
"M" Creek	P2009-06	4.2							PND 2009
	19		12	12	12	67			URS 2003a
	PLX07		4–32				93–107	3.6–4.3	MBJ 1998
No Name Drainage 1	PLX08	1.35	0				40–70	1.4–1.5	MBJ 1998
	PLX08								MBJ 1998
	PLX08								MBJ 1998

Stream Name	Site Location [1,2]	Approximate Drainage Area (sq. mi.)	Stream Width (ft)				Bankfull		Reference
			Gravel in Channel	Ordinary High Water [3]	Top of Low Flow Banks [4]	Flood-plain Breaks [5]	Width (ft)	Max Depth (ft)	
"L" Creek	P2009-07	39.1							PND 2009
	18		3	3	3	90			URS 2003a
	PLX09		16–18				85–145	4.0–4.7	MBJ 1998
"K" Creek	P2009-08	18.7							PND 2009
	17		3	3	3	100			URS 2003a
	PLX10		5–10				54–89	2.2–3.4	MBJ 1998
"J" Creek	P2009-09	2.2							PND 2009
	16		17	17	17	110			URS 2003a
	PLX11		11–13				35–57	2.7–4.5	MBJ 1998
"I" Creek	P2009-10	22.6							PND 2009
	15		12	12	12	160			URS 2003a
	PLX12		45–53				66	2.8–3.1	MBJ 1998
"G" Creek	P2009-11	16.7							PND 2009
	13		18	18	18	50			URS 2003a
	PLX15		13–16				51–56	2.4–5.2	MBJ 1998
"F" Creek	P2009-12	18.4							PND 2009
	12		27	27	27	70			URS 2003a
	PLX16		18–19				93–111	4.1	MBJ 1998
"C" Creek	P2009-16	1.8							PND 2009
	1		10	10	10	200			URS 2003a
	PLX22		11–13				96–104	2.5–3.6	MBJ 1998
Creek 23	P2009-17	0.5							PND 2009
	PLX23		0–6				39–60	2	MBJ 1998
"B" Creek	P2009-18	2							PND 2009
	27		37	41	41	205			URS 2003a
	PLX24		18–60				101–109	5.7–6.5	MBJ 1998

Stream Name	Site Location [1,2]	Approximate Drainage Area (sq. mi.)	Stream Width (ft)				Bankfull		Reference
			Gravel in Channel	Ordinary High Water [3]	Top of Low Flow Banks [4]	Flood-plain Breaks [5]	Width (ft)	Max Depth (ft)	
"S" Creek	P2009-19	7.7							PND 2009
	PLX26		18–26				46–68	2.9–4.4	MBJ 1998
"R" Creek	P2009-20	0.7							PND 2009
	PLX27		18–64				41–79	2.0–3.2	MBJ 1998

Notes:

[1] Based on a visual inspection of the maps contained in the referenced documents, the pipeline alignment monitored by URS (2003a) appears to be approximately the same pipeline alignment monitored by PND (2009a).

[2] Based on a visual inspection of the maps contained in the referenced documents, the pipeline alignment monitored by Michael Baker Jr., Inc. (1998) is usually within one-half mile of the pipeline alignment monitored by PND (2009a). It is often closer to the coast.

[3] The ordinary high water line was generally taken to be the break between the upland vegetation and little or no vegetation. Often there was a cut bank present at this location.

[4] Typically the top of the low flow bank was taken to be the top of the cut bank. However, in some of the streams there was a feature farther from the gravel bottom that appeared to represent a low bank.

[5] The floodplain break on either side of the channel is defined as the point at which the nearly level floodplain begins to slope more steeply toward the channel, usually with a slope equal to or greater than 5 horizontal to 1 vertical.

cfs = cubic feet per second
fps = feet per second
ft = feet
sq. mi. = square mile

TABLE 3-9: SUMMARY OF FLOOD-PEAK DISCHARGE ESTIMATES AT PROPOSED PROJECT PIPELINE AND ROAD CROSSINGS

Stream Name	Site	Drainage Area (sq. mi.)	Annual Flood-Peak Discharge (cfs)							
			2-Yr[1] (cfs)	5-Yr[1] (cfs)	10-Yr[1] (cfs)	25-Yr[1] (cfs)	50-Yr[1] (cfs)	100-Yr[1] (cfs)	200-Yr[1] (cfs)	500-Yr[1] (cfs)
West Badami Creek	P2009-01	52.1	953	1,476	1,819	2,243	2,551	2,851	3,143	3,523
Middle Badami Creek	P2009-02	23.1	462	728	905	1,126	1,287	1,444	1,598	1,800
East Badami Creek	P2009-03	95.8	1,641	2,506	3,070	3,763	4,263	4,747	5,219	5,831
"O" Creek	P2009-04	5.6	130	212	267	337	389	439	490	556
"N" Creek	P2009-05	17.8	365	579	722	900	1,030	1,158	1,283	1,447
"M" Creek	P2009-06	4.2	101	165	209	264	306	346	386	439
"L" Creek	P2009-07	39.1	738	1,151	1,423	1,760	2,005	2,244	2,478	2,782
"K" Creek	P2009-08	18.7	382	605	754	939	1,075	1,208	1,338	1,509
"J" Creek	P2009-09	2.2	56	93	119	151	176	200	223	255
"I" Creek	P2009-10	22.6	453	714	888	1,105	1,263	1,417	1,569	1,767
"G" Creek	P2009-11	16.7	345	549	684	854	978	1,099	1,219	1,375
"F" Creek	P2009-12	18.4	377	598	745	929	1,063	1,194	1,324	1,492
Creek 18a	P2009-13	0.9	27	45	58	75	87	100	112	128
Creek 18a	R2009-01	0.6	17	29	38	49	57	66	74	85
"E" Creek	P2009-14	9.9	217	349	437	549	631	711	790	894
"E" Creek	R2009-02	9.6	211	339	425	533	613	691	768	869
"D" Creek	P2009-15	8.5	190	306	385	484	556	627	698	790
"D" Creek	R2009-03	8.1	180	291	366	460	529	598	665	753
"C" Creek	P2009-16	1.8	47	78	100	127	148	168	189	215
"C" Creek	R2009-04	1.5	40	67	85	109	127	144	162	185
Creek 23	P2009-17	0.5	16	28	36	47	55	63	71	82
Creek 23	R2009-05	0.2	6	11	14	19	22	26	29	33
"B" Creek	P2009-18	2	52	86	110	140	162	184	206	236
"B" Creek	R2009-06	0.6	19	32	41	53	62	71	80	92
"B" Creek	R2009-07	0.2	8	14	18	23	28	32	36	41

Stream Name	Site	Drainage Area (sq. mi.)	Annual Flood-Peak Discharge (cfs)							
			2-Yr[1] (cfs)	5-Yr[1] (cfs)	10-Yr[1] (cfs)	25-Yr[1] (cfs)	50-Yr[1] (cfs)	100-Yr[1] (cfs)	200-Yr[1] (cfs)	500-Yr[1] (cfs)
"S" Creek	P2009-19	7.7	174	281	353	444	511	577	642	727
"S" Creek	R2009-08	6.3	144	235	296	372	429	485	540	613
"R" Creek	P2009-20	0.7	19	33	42	54	64	73	82	84
"R" Creek	R2009-09	2.4	61	102	129	165	191	217	242	277

Notes:
[1] On average, a flood-peak discharge equal to or greater than the discharge specified below can be expected to occur once every T-years.
[2] The annual flood-peak discharges associated with the T-year event were computed by PND (2009a) based on the methods proposed by Curran et al. (2003).
cfs = cubic feet per second
sq. mi. = square mile

Lakes and Ponds

Natural and artificial (gravel mine sites) lakes are the most common sources of fresh water supply on the North Slope. Fresh water is used for potable water for facilities; for exploration drilling, and development drilling; and for ice road construction. Although the coastal plain in the Project area has numerous lakes and ponds, past investigations suggest that most of them are less than 6 feet in depth and freeze to the bottom or very near the bottom in most years (Aldrich 1981).

In the spring of 2002, 17 lakes (Table 3-10, Figure 3-8) were identified, on the basis of aerial photographic interpretation, as being possible winter water sources (Alaska Interstate Construction 2002). The 17 lakes were inspected during the first week of May 2002, at which time 16 were frozen to the bottom, and the seventeenth had 7 feet of ice and 6 inches of muddy water below the ice. Lake depths were measured in what was thought to be the deepest part of each lake, and ranged from 1.7–7.0 feet. The median depth of the 17 lakes was 3.6 feet.

Lake data were also collected by the University of Alaska in 2006, 2007, and 2008 (White et al. 2006; Myerchin et al. 2007, 2008) (Table 3-10, Figure 3-8). Eleven natural lakes and two flooded material sites were sampled. Of the 11 lakes, the maximum recorded depth of water below the ice was 1.6 feet. Three of the lakes had no water below the ice and the median depth below the ice was 0.8 foot. The two gravel mine sites, the Shaviovik site and the Badami Development site, had as much as 28 and 7 feet of water below the ice, respectively.

Parameters included in Table 3-11 are: surface area, depth, total volume, authorized volume, and presence or absence of fish. Of the 31 lakes and mine sites listed in Table 3-11, only six have a depth of 6 feet or deeper and, of those, five are or were gravel mine sites. Lakes that have previously been permitted for water or ice removal in the Project area are listed in Table 3-11 and shown on Figure 3-9.

TABLE 3-10: SUMMARY OF AVAILABLE DATA ON LATE WINTER LAKE ICE THICKNESS AND WATER DEPTH ALONG COAST BETWEEN SAGAVANIRKTOK RIVER AND POINT THOMSON

Lake ID	Location			Date Data Collected			Ice Thick-ness (ft)	Water Depth Below Ice (ft)	Description	Reference
	Latitude (N)	Longitude (W)	Datum	Year	Month	Day				
	(decimal degrees)									
W0608 H2	70.154020	148.482330	NAD83	2006	May	1	3.0	0.0	West of Sagavanirktok R.	White 2006
W0608 H3	70.153390	148.478320	NAD83	2006	May	1	3.3	0.0	West of Sagavanirktok R.	White 2006
W0608 H1	70.154620	148.477940	NAD83	2006	May	1	3.0	0.0	West of Sagavanirktok R.	White 2006
W0608 H5	70.154150	148.476590	NAD83	2006	May	1	2.6	0.0	West of Sagavanirktok R.	White 2006
W0608 H6	70.154950	148.476330	NAD83	2006	May	1	3.3	0.0	West of Sagavanirktok R.	White 2006
W0608 H4	70.153210	148.475980	NAD83	2006	May	1	2.2	0.0	West of Sagavanirktok R.	White 2006
W0608 H7	70.155430	148.475920	NAD83	2006	May	1	2.7	0.0	West of Sagavanirktok R.	White 2006
W0710	70.085667	148.183567	NAD83	2007	May	4	5.4	1.6	East of Sagavanirktok R.	Myerchin 2007
W0609 H2	70.213630	148.178210	NAD83	2006	May	2	4.5	0.8	West of Sagavanirktok R.	White 2006
W0609 C	70.214120	148.177520	NAD83	2006	May	2	4.5	1.5	West of Sagavanirktok R.	White 2006
W0603 H4	70.143030	148.081510	NAD83	2006	April	30	---	0.0	East of Sagavanirktok R.	White 2006
W0603 H3	70.141080	148.079560	NAD83	2006	April	30	2.6	0.0	East of Sagavanirktok R.	White 2006
W0603 H2	70.140730	148.074780	NAD83	2006	April	30	2.7	0.0	East of Sagavanirktok R.	White 2006
W0603 H1	70.142550	148.070110	NAD83	2006	April	30	0.8	0.0	East of Sagavanirktok R.	White 2006
W0610 H2	70.083960	147.784620	NAD83	2006	May	2	5.4	0.8	East of Kadleroshilik R.	White 2006
W0610 H1	70.082190	147.780240	NAD83	2006	May	2	3.9	0.0	East of Kadleroshilik R.	White 2006
W0611 H1	70.144420	147.460070	NAD83	2006	May	2	4.7	0.0	West of Shaviovik R.	White 2006
W0611 H2	70.144330	147.457000	NAD83	2006	May	2	5.5	0.4	West of Shaviovik R.	White 2006
W0708	70.161583	147.419017	NAD83	2007	May	8	4.9	1.0	West of Shaviovik R.	Myerchin 2007
W0602 H6	70.165420	147.399120	NAD83	2006	April	30	1.7	0.0	West of Shaviovik R.	White 2006
W0602 H1	70.164470	147.398910	NAD83	2006	April	30	1.6	0.0	West of Shaviovik R.	White 2006
W0602 H2	70.163960	147.397220	NAD83	2006	April	30	1.8	0.0	West of Shaviovik R.	White 2006
W0602 H3	70.162250	147.394730	NAD83	2006	April	30	0.9	0.0	West of Shaviovik R.	White 2006
W0602 H5	70.164080	147.393300	NAD83	2006	April	30	1.4	0.0	West of Shaviovik R.	White 2006

Lake ID	Location			Date Data Collected			Ice Thick-ness (ft)	Water Depth Below Ice (ft)	Description	Reference
	Latitude (N)	Longitude (W)	Datum	Year	Month	Day				
	(decimal degrees)									
W0602 H4	70.162940	147.391340	NAD83	2006	April	30	1.6	0.0	West of Shaviovik R.	White 2006
Shaviovik C	70.158430	147.254150	NAD83	2006	May	3	5.1	28.0	Shaviovik R gravel pit.	White 2006
Shaviovik	70.158267	147.252550	NAD83	2007	May	8	5.3	11.2	Shaviovik R gravel pit.	Myerchin 2007
Shaviovik	70.158367	147.252233	NAD83	2008	May	16	6.3	8.0	Shaviovik R gravel pit.	Myerchin 2008
W0707	70.018583	147.193950	NAD83	2007	May	8	4.7	0.9	East of Shaviovik / Kavik Rivers.	Myerchin 2007
Badami C	70.130260	146.998720	NAD83	2006	April	30	~6.5	22.2	Badami gravel pit.	White 2006
Badami H2	70.129750	146.998020	NAD83	2006	April	30	7	15.8	Badami gravel pit.	White 2006
Badami H1	70.129433	147.004250	NAD83	2007	May	8	6.4	0.1	Badami gravel pit.	Myerchin 2007
Badami H2	70.129467	147.004100	NAD83	2007	May	8	7.0	5.4	Badami gravel pit.	Myerchin 2007
Badami	70.129450	146.999850	NAD83	2008	May	16	6.4	12.1	Badami gravel pit.	Myerchin 2008
#1	70.133106	146.964533	NAD83	2002	May	5	4.5	0.0	Southeast of Badami	AIC 2002
W0612 H1	70.135900	146.898880	NAD83	2006	May	3	4.8	0.4	Southwest of Bullen Point.	White 2006
W0612 H2	70.014080	146.895690	NAD83	2006	May	3	4.9	0.0	Southwest of Bullen Point.	White 2006
#2	70.134539	146.875311	NAD83	2002	May	5	3.0	0.0	Southwest of Bullen Point.	AIC 2002
#3	70.151091	146.805522	NAD83	2002	May	5	4.5	0.0	Southeast of Bullen Point.	AIC 2002
#4 West	70.148305	146.794067	NAD83	2002	May	5	4.0	0.0	Southeast of Bullen Point.	AIC 2002
#4 East	70.150167	146.783467	NAD83	2002	May	5	3.8	0.0	Southeast of Bullen Point.	AIC 2002
#5	70.153384	146.689705	NAD83	2002	May	5	3.0	0.0	Southwest of Point Gorden.	AIC 2002
#7	70.167197	146.670436	NAD83	2002	May	5	2.0	0.0	Southwest of Point Gorden.	AIC 2002
#6	70.163000	146.669194	NAD83	2002	May	5	1.7	0.0	Southwest of Point Gorden.	AIC 2002
#8	70.166253	146.583928	NAD83	2002	May	5	3.0	0.0	Southeast of Point Gorden.	AIC 2002
#9	70.169027	146.514820	NAD83	2002	May	5	3.6	0.0	South of Point Hopson.	AIC 2002
#10 West	70.167614	146.417045	NAD83	2002	May	5	4.2	0.0	Southeast of Point Sweeney.	AIC 2002
#10 East	70.168045	146.407872	NAD83	2002	May	5	3.5	0.0	Southeast of Point Sweeney.	AIC 2002
#13	70.152275	146.352092	NAD83	2002	May	4	5.0	0.0	Southwest of Point Thomson.	AIC 2002
#12	70.167509	146.347439	NAD83	2002	May	4	3.0	0.0	Southwest of Point Thomson.	AIC 2002
#11	70.169647	146.346397	NAD83	2002	May	4	4.0	0.0	Southwest of Point Thomson.	AIC 2002

Lake ID	Location			Date Data Collected			Ice Thick-ness (ft)	Water Depth Below Ice (ft)	Description	Reference
	Latitude (N)	Longitude (W)	Datum	Year	Month	Day				
	(decimal degrees)									
#14	70.165453	146.281375	NAD83	2002	May	4	3.3	0.0	Southeast of Point Thomson.	AIC 2002
#17 North	70.121249	146.261728	NAD83	2002	May	4	7.0	0.0	Southeast of Point Thomson.	AIC 2002
#17 South	70.115538	146.249442	NAD83	2002	May	4	6.0	0.0	Southeast of Point Thomson.	AIC 2002
#17 East	70.118742	146.244009	NAD83	2002	May	4	7.0	0.5	Southeast of Point Thomson.	AIC 2002
W0709	70.118783	146.241150	NAD83	2007	May	8	5.4	1.5	Southeast of Point Thomson / On "B" Creek / Same as Lake #17.	Myerchin 2007
#15	70.154103	146.192497	NAD83	2002	May	4	3.5	0.0	Southeast of Point Thomson.	AIC 2002
#16	70.150275	146.140558	NAD83	2002	May	4	4.0	0.0	Southeast of Point Thomson.	AIC 2002

Notes:
ID = Identification
ft = feet

TABLE 3-11: PERMITTED WATER/ICE SOURCES

Water Source	Surface Area (ac)	Depth (ft)	Total Volume (MG)	Authorized Volume Water/Ice (MG)[1]	Fish
Lake 25	166	~5	270.46	54.09	No
Lake 24	118	~5	192.25	38.45	No
Lake 23	183	~5	298.15	59.63	No
Lake 22	181	~5	294.9	58.98	No
Lake 21	196	~5	319.33	63.87	No
Lake 20	68	~5	110.79	22.16	No
Lake 18	182	~5	296.52	59.3	No
Lake 19	32	~5	52.14	10.42	No
Shaviovik Mine	13	48	203.33	21.36	Yes
C-1 Mine Site	11	35	43.56	9.38	Yes
Lake 17	173	7.5	140.93	5.64	Yes
Lake 1	33	4.5	16.13	3.23	No
Lake 2	37	3	12.60	2.41	No
Lake 3	15	3.8	6.19	1.24	No
Lake 4 E/W	93	4	40.41	8.08	No
Lake 7	22	2	4.78	0.96	No
Lake 6	12	1.7	2.22	0.44	No
Lake 5	11	3	3.58	0.72	No
Lake 8	13	3	4.24	0.85	No
Lake 9	31	3.6	12.12	2.42	No
Lake 10	65	4	28.24	5.64	No
Lake 11	20	4	8.70	1.74	No
Lake 12	23	3	7.49	1.5	No
Lake 13	40	5	21.72	4.34	No
Lake 14	8	3.3	2.87	.57	No
Lake 15	12	3.5	4.56	0.91	No
Lake 16	22	4	9.56	1.91	No
Duck Island Mine Site	85.2	69	1,915.84	1,721.46	No
Sag Mine Site C	41	38.2	77	7	Yes
Badami Mine Site	22	40	≅92.55	4.83	Yes
Unnamed Lake T11N, R17E, SW¼ Sec.19 UM	15	~5	24.44	4.89	No
Sagavanirktok River				Not specified	
Beaufort Sea				Not specified	

Notes:
[1] Combined total of 179.53 acre-feet of water and/or ice were authorized under ADNR Temporary Water Use Permits A2008-123 through A2008-130.
ac = acres ft = feet MG = millions of gallons

Ground Water

The Project area lies within a zone of continuous permafrost. Along the ACP, the thickness of the permafrost is reported to range from 1,200–2,000 feet (Hydrocon 1982). Groundwater is restricted to thawed areas that form beneath rivers and lakes, the seasonally thawed area (active layer) above the permafrost, saline zones within the permafrost, and beneath the permafrost.

Groundwater beneath the permafrost is generally considered to be brackish to saline (Williams and van Everdingen 1973). Saline groundwater also occurs within the permafrost, in locations where dissolved salts depress the freezing point of the water.

During the summer, groundwater occurs within the active (thawed) layer above the permafrost. The thickness of the active layer is typically about 1.5 feet, but may range from as little as 1 foot under dense organic mats to about 3 feet in coarse-textured soil (Rawlinson 1983).

Within the Project area, continuously thawed areas (i.e., thaw bulbs) containing year-round unfrozen groundwater, are probably only present under rivers and lakes that are more than 6 or 7 feet deep. As discussed previously under Lakes and Ponds, this is probably a rare occurrence within the Project area.

3.1.3.2 Hydrologic Processes

Precipitation

Precipitation on the ACP generally occurs as rainfall from June–September and as snowfall for the remaining months of the year. Precipitation intensity is light but occurrence is frequent. During the summer, a high incidence of "trace" amounts (less than 0.01 inch) is generally considered to result in under-reporting the total precipitation.

Along the coast, between the Sagavanirktok and Staines rivers, the average annual rainfall probably varies from about 8.4–9.4 inches, the long-term average values reported for Prudhoe Bay and Barter Island (Table 3-12 - NRCS 2009). Within the ACP province, between the Sagavanirktok and Staines rivers, the average annual precipitation probably varies between about 8.4–10 inches (Jones and Fahl 1994). Within the Arctic Foothills Province, between the Sagavanirktok and the Staines rivers, the average annual precipitation probably varies between about 13–20 inches (Jones and Fahl 1994). The monthly distribution of the precipitation in the ACP and the Arctic Foothills Provinces is probably similar to that shown in Table 3-12 for Prudhoe Bay and Barter Island.

Snow lasts up to nine months of the year on the ACP. The water contained in the snowpack is an important component of the region's hydrologic cycle. Measurements in 2006, 2007, and 2008 (Kane et al. 2006; Berezovskaya et al. 2007; Berezovskaya et al. 2008), between the Sagavanirktok and Staines rivers, indicate that the snowpack on the ACP may generally contain about 3.5 inches of water before break-up (Table 3-13). Measurements over the same period of time indicate that the snowpack in the Arctic Foothills Province may generally contain about 3.1 inches of water before break-up. Although the computed averages are different for the ACP and the Arctic Foothills, the standard deviations are large enough that the computed differences are probably not significant.

TABLE 3-12: AVERAGE MONTHLY PRECIPITATION FOR PRUDHOE BAY AND BARTER ISLAND ALASKA[1]

Site Name	Elevation (ft)	Total Monthly Precipitation												Total
		Jan (in)	Feb (in)	Mar (in)	Apr (in)	May (in)	Jun (in)	Jul (in)	Aug (in)	Sep (in)	Oct (in)	Nov (in)	Dec (in)	Annual Precip. (in)
Barter Island	30	0.6	0.5	0.4	0.4	0.4	1	1.2	1.5	1	1	0.7	0.7	9.4
Prudhoe Bay	30	0.6	0.5	0.4	0.3	0.3	0.7	1.1	1.3	0.9	0.9	0.7	0.7	8.4

Notes:
[1] The averages are based on data collected between 1971 and 2000.
ft = feet
in = inch
Precip. = Precipitation

TABLE 3-13: SPRING SNOW DEPTH AND SNOW WATER EQUIVALENT MEASUREMENTS[1]

Site ID	Elevation (NGVD 29) (ft)	Latitude (N) (NAD 83)	Longitude (W) (NAD 83)	Physiographic Province	Snow Depth			Snow Water Equivalent		
		(decimal degrees)			2006 (in)	2007 (in)	2008 (in)	2006 (in)	2007 (in)	2008 (in)
LBP0701	43	70.0879	148.189	Coastal Plain		8.4			3.3[2]	
LBP0701-L	43	69.0879	148.189	Coastal Plain		6.9			3.4[2]	
WH2	23	70.2148	148.177	Coastal Plain	15.2			5.5		
L15	36	70.1438	148.068	Coastal Plain	13.7	12.0		4.8	3.1	
W0807	----	70.0805	147.933	Coastal Plain			7.3			3.1
BL1	33	70.1184	147.925	Coastal Plain	21.1		12.4	4.9		2.6
WH4	110	70.0814	147.777	Coastal Plain	16.5			4.1		
BL2	23	70.1126	147.649	Coastal Plain	13.7			3.7		
LBP0706	150	69.9653	147.573	Coastal Plain		13.4			3.5	
LBP0706-L	150	69.9653	147.573	Coastal Plain		9.0			2.0	
WH3	26	70.1443	147.463	Coastal Plain	15.3			4.4		

Site ID	Elevation (NGVD 29) (ft)	Latitude (N) (NAD 83) (decimal degrees)	Longitude (W) (NAD 83)	Physiographic Province	Snow Depth 2006 (in)	Snow Depth 2007 (in)	Snow Depth 2008 (in)	Snow Water Equivalent 2006 (in)	Snow Water Equivalent 2007 (in)	Snow Water Equivalent 2008 (in)
LPB0705	26	70.1625	147.422	Coastal Plain		12.3			2.1	
LPB0705-L	26	70.1625	147.422	Coastal Plain		12.6			2.4	
L43	16	70.1681	147.404	Coastal Plain	10.4			2.4		
L43-Lake	16	70.1645	147.399	Coastal Plain	9.3			2.7		
BL4	203	70.0566	147.333	Coastal Plain	17.2		10.5	4.7		2.9
SHAV	16	70.1586	147.259	Coastal Plain	14.0	19.6	14.7	3.6	3.2	6.0
SHAV-L	16	70.1586	147.259	Coastal Plain		16.9			3.7	
LBP0707	69	70.0200	147.195	Coastal Plain		19.9			5.6	
LBP0707-L	69	70.0200	147.195	Coastal Plain		12.8			4.1	
L12	13	70.1342	147.164	Coastal Plain	12.2			4.4		
BL3	140	70.0516	147.137	Coastal Plain	14.2		14.8	3.7		5.0
BDM	13	70.1310	147.000	Coastal Plain	5.9	9.6	1.1	1.2	1.4	0.2
BDM-L	13	70.1310	147.000	Coastal Plain		5.7			0.9	
MD4	370	69.7544	146.954	Coastal Plain	11.4			2.3		
DBM8	85	70.0799	146.819	Coastal Plain			16.8			5.6
BL5	100	70.0689	146.769	Coastal Plain	19.1			5.5		
MD5	430	69.7721	146.731	Coastal Plain	10.0			2.6		
BL6	95	70.1073	146.421	Coastal Plain	9.3		13.9	2.7		5.3
LBP0709	13	70.1201	146.240	Coastal Plain		18.1			3.3	
LBP0709-L	13	70.1201	146.240	Coastal Plain		7.3			---	
Coastal Plain - Number of Sites Sampled:					17	15	8	17	14	8
Coastal Plain - Average:					**13.4**	**12.3**	**11.4**	**3.7**	**3.0**	**3.8**
Coastal Plain - Standard Deviation:					3.9	4.6	5.1	1.2	1.2	2.0
DBM4	1,400	69.2156	148.552	Foothills		19.1	13.3		3.7	2.4
UP1	640	69.2276	148.454	Foothills	9.4	14.7		1.9	3.0	
DBR5	880	69.8106	148.326	Foothills		18.0			4.1	
MD1	720	69.8350	148.317	Foothills	13.2			4.6		

Site ID	Elevation (NGVD 29) (ft)	Latitude (N) (NAD 83)	Longitude (W) (NAD 83)	Physiographic Province	Snow Depth			Snow Water Equivalent		
		(decimal degrees)			2006 (in)	2007 (in)	2008 (in)	2006 (in)	2007 (in)	2008 (in)
DBM5	690	69.5495	147.942	Foothills		20.2			5.6	
UP2	1,000	69.3439	147.850	Foothills	12.6	16.0	6.9	2.8	2.4	1.6
MD2	1,100	69.7688	147.849	Foothills	14.2		12.4	3.4		3.4
UP3	1,300	69.4356	147.460	Foothills	14.5	18.7	18.2	2.6	3.9	2.6
MD3	1,000	69.7170	147.380	Foothills	19.8	12.7		4.2	3.0	
DBM6	650	69.6734	146.901	Foothills		7.8			1.9	
MD6	560	69.7772	146.530	Foothills	5.3			2.0		
UP4	1,100	69.5689	146.530	Foothills	10.0	20.6	13.7	2.3	5.2	3.2
Foothills–Number of Sites Sampled:					8	9	5	8	9	5
Foothills–Average:					**12.4**	**16.4**	**12.9**	**3.0**	**3.6**	**2.6**
Foothills–Standard Deviation:					4.3	4.2	4.0	1.0	1.2	0.7

Notes:
[1] Measurements were generally made the last week of April and/or the first week of May.
[2] Values for the 2007 snow water equivalent at sites LBP0701 and LBP0701-L represent adjusted values to account for a late spring storm.
ft = feet
ID = identification
in = inch
NAD 83 = North American Datum
NGVD 29 = National Geodetic Vertical Datum of 1929
Precip. = Precipitation

Snowmelt and Rainfall Floods

The annual maximum flood-peak discharge, on streams passing through the ACP, typically occurs during spring break-up. Although there have been instances where a late summer rainstorm produced the annual maximum flood-peak discharge, this appears to be a rare occurrence. Two known occurrences are Nunavak Creek (near Barrow) at the USGS gage in 1993, and the Sagavanirktok River near its mouth in 1992. For the streams crossed by the Project pipeline and road routes, it is anticipated that even a 100- or 200-year event would likely occur as a spring break-up event.

The amount of snowfall and the timing of the snowmelt runoff are probably the two main factors that affect the magnitude of the annual flood peak discharge. Cool temperatures until late in the spring with a sudden rise in temperatures will generally result in larger flood-peak discharge at the beginning of the season. However, depending on air temperatures or if the wind is particularly strong or steady, the snow water equivalent of the snowpack can be significantly reduced by evaporation and sublimation before the beginning of snowmelt. Although a single flood peak is most common, multiple peaks regularly occur.

For streams in the Project area, break-up generally begins with the drainage channel completely full of blown snow, to the point that the channel is often indistinguishable from the floodplain on either side. As the air temperature begins to increase, the water content of the snow within the drainage channel also increases, giving the snow a gray color. Occasionally, water will begin to pool on the surface of the snow within the channel. As break-up progresses, it is often possible to watch the leading edge of the water moving down the channel. The time between the leading edge passing a point on the channel and the spring break-up flood-peak discharge passing the same point can be as little as less than one to three days.

Most of the streams in the Project area are dry or nearly dry at freeze-up, and freeze completely during the winter. In general, few ice floes are observed during break-up, and then only on the larger rivers and streams. Slush floes and water flowing over ice frozen to the bed are common during break-up. In some cases the water flows on top of the blown snow, and may channel through the snow on the floodplain rather than in the actual stream channel. Snow blockage in the channel and on the floodplain can sometimes cause the maximum water surface elevation to occur before, and at a discharge less than, the peak discharge.

Typical Discharges

Within the Project area, it is unlikely that any of the streams have surface flow during the winter. Surface flow will generally begin the last week of May or the first week of June. The discharge will increase to the spring break-up flood-peak discharge and then recede to a small fraction of the spring break-up flood-peak discharge. During the summer and fall, the discharge will increase in response to rainfall, but it will typically only be a small percentage of the spring break-up flood-peak discharge.

In 2003, URS monitored “B” Creek at approximately the location of the Project material site/water supply location (Figure 3-7). The rising limb of the 2003 hydrograph was approximately 2.5 days in length, during which time the discharge increased from 0 to more than 1,500 cubic feet per second (cfs). The discharge then receded, and 10 days later the average daily discharge was 8.6 cfs. Figure 3-10 presents a plot of the hydrograph during spring break-up and Table 3-14 presents a summary of the discharge and runoff volume data collected throughout the monitoring period.

An estimate of the mean monthly flow on each of the streams is presented in Table 3-15. June has the highest mean monthly flow, July has the next highest and August and September are about the same. The average monthly flow in June is generally more than 20 times the flow in August and September, and more than 7 times the flow in July.

TABLE 3-14: RUNOFF ON "B" CREEK, NEAR PROPOSED MATERIAL SITE/WATER SUPPLY

Date	Mean Daily Discharge[1] (cfs)	Daily Volume		Cumulative Volume		General Footnotes (see below)
		(Acre-ft)	(Million Gallons)[2]	(Acre-ft)	(Million Gallons)[2]	
3-Jun-03	0	0.0	0.0	0	0	3
4-Jun-03	40	79.3	25.9	79	26	4,5
5-Jun-03	200	396.7	129.3	476	155	5
6-Jun-03	760	1,507.4	491.2	1,983	646	5
7-Jun-03	360	714.0	232.7	2,698	879	5
8-Jun-03	200	396.7	129.3	3,094	1,008	5
9-Jun-03	100	198.3	64.6	3,293	1,073	5
10-Jun-03	67	132.9	43.3	3,425	1,116	6
11-Jun-03	50	99.2	32.3	3,525	1,149	6
12-Jun-03	33	65.5	21.3	3,590	1,170	6
13-Jun-03	27	53.6	17.5	3,644	1,187	6
14-Jun-03	17	33.5	10.9	3,677	1,198	7
15-Jun-03	12	24.2	7.9	3,701	1,206	7
16-Jun-03	8.6	17.1	5.6	3,718	1,212	7
17-Jun-03	6.8	13.5	4.4	3,732	1,216	7
18-Jun-03	5.5	10.9	3.6	3,743	1,220	7
19-Jun-03	4.4	8.7	2.9	3,752	1,222	7
20-Jun-03	3.7	7.3	2.4	3,759	1,225	7
21-Jun-03	3.2	6.2	2.0	3,765	1,227	7
22-Jun-03	2.7	5.3	1.7	3,770	1,229	7
23-Jun-03	2.1	4.1	1.4	3,775	1,230	7
24-Jun-03	1.7	3.4	1.1	3,778	1,231	7
25-Jun-03	1.4	2.8	0.9	3,781	1,232	7
26-Jun-03	1.3	2.5	0.8	3,783	1,233	7
27-Jun-03	1.2	2.3	0.8	3,786	1,234	7
28-Jun-03	1.0	2.0	0.6	3,788	1,234	7
29-Jun-03	0.9	1.7	0.6	3,789	1,235	7
30-Jun-03	0.8	1.6	0.5	3,791	1,235	7

Date	Mean Daily Discharge[1] (cfs)	Daily Volume		Cumulative Volume		General Footnotes (see below)
		(Acre-ft)	(Million Gallons)[2]	(Acre-ft)	(Million Gallons)[2]	
1-Jul-03	0.8	1.5	0.5	3,792	1,236	7
2-Jul-03	0.9	1.7	0.6	3,794	1,236	7
3-Jul-03	1.1	2.1	0.7	3,796	1,237	7
4-Jul-03	1.6	3.2	1.1	3,800	1,238	7
5-Jul-03	1.4	2.8	0.9	3,802	1,239	7
6-Jul-03	1.3	2.5	0.8	3,805	1,240	7
7-Jul-03	1.2	2.4	0.8	3,807	1,241	7
8-Jul-03	1.2	2.3	0.7	3,810	1,241	7
9-Jul-03	1.2	2.5	0.8	3,812	1,242	7
10-Jul-03	1.1	2.2	0.7	3,814	1,243	7
11-Jul-03	1.2	2.4	0.8	3,817	1,244	7
12-Jul-03	1.2	2.3	0.8	3,819	1,244	7
13-Jul-03	1.2	2.3	0.8	3,821	1,245	7
14-Jul-03	1.0	2.1	0.7	3,823	1,246	7
15-Jul-03	1.3	2.7	0.9	3,826	1,247	7
16-Jul-03	2.2	4.3	1.4	3,830	1,248	7
17-Jul-03	1.6	3.3	1.1	3,834	1,249	7
18-Jul-03	1.3	2.7	0.9	3,836	1,250	7
19-Jul-03	1.2	2.4	0.8	3,839	1,251	7
20-Jul-03	1.2	2.4	0.8	3,841	1,252	7
21-Jul-03	1.2	2.5	0.8	3,844	1,252	7
22-Jul-03	1.1	2.3	0.7	3,846	1,253	7
23-Jul-03	1.0	2.1	0.7	3,848	1,254	7
24-Jul-03	1.1	2.2	0.7	3,850	1,255	7
25-Jul-03	1.5	3.1	1.0	3,853	1,256	7
26-Jul-03	2.6	5.1	1.7	3,858	1,257	7
27-Jul-03	2.2	4.3	1.4	3,862	1,259	7
28-Jul-03	1.9	3.7	1.2	3,866	1,260	7
29-Jul-03	1.5	3.1	1.0	3,869	1,261	7
30-Jul-03	1.5	2.9	0.9	3,872	1,262	7
31-Jul-03	1.4	2.8	0.9	3,875	1,263	7
1-Aug-03	1.3	2.6	0.9	3,878	1,264	7
2-Aug-03	1.2	2.3	0.8	3,880	1,264	7
3-Aug-03	1.1	2.2	0.7	3,882	1,265	7
4-Aug-03	1.0	2.0	0.7	3,884	1,266	7
5-Aug-03	1.1	2.1	0.7	3,886	1,266	7
6-Aug-03	0.9	1.8	0.6	3,888	1,267	7
7-Aug-03	0.9	1.8	0.6	3,890	1,268	7
8-Aug-03	0.9	1.8	0.6	3,892	1,268	7
9-Aug-03	1.1	2.2	0.7	3,894	1,269	7

Date	Mean Daily Discharge[1] (cfs)	Daily Volume		Cumulative Volume		General Footnotes (see below)
		(Acre-ft)	(Million Gallons)[2]	(Acre-ft)	(Million Gallons)[2]	
10-Aug-03	4.6	9.2	3.0	3,903	1,272	7
11-Aug-03	7.7	15.3	5.0	3,918	1,277	7
12-Aug-03	6.5	12.9	4.2	3,931	1,281	7
13-Aug-03	7.9	15.7	5.1	3,947	1,286	7
14-Aug-03	10.9	21.5	7.0	3,969	1,293	7
15-Aug-03	14.4	28.6	9.3	3,997	1,302	7
16-Aug-03	12.3	24.5	8.0	4,022	1,310	7

Notes:

[1] Discharge measurements were made once daily between 4 June and 13 June with the exception of 6 June, when weather conditions would not permit a site visit. From 13 June–16 August, a pressure transducer/data logger was used to record the water surface elevation every 30 minutes. The water surface elevation data were converted to a discharge value using a water surface elevation vs. discharge rating curve.

[2] U.S. Gallons.

[3] Water was ponding in the channel, but no flow had begun.

[4] For the purposes of this computation, flow was estimated to have initiated at 0:00 on 4 June.

[5] The mean daily discharge was determined graphically from the streamflow hydrograph. The hydrograph was constructed using the discharge measurements and three additional data points from 6 June. The discharge at 0:00 on 6 June is a linear extrapolation of measured values on 4 and 5 June. The discharge at 24:00 on 6 June is a linear extrapolation of measured values on 7 and 8 June. The discharge at 12:00 on 6 June is the estimated peak discharge value.

[6] The mean daily discharge value was assumed equal to the measured discharge.

[7] Using the measured discharge and water surface elevation values on 13 June and 2 July, a logarithmic relationship was developed relating water surface elevation in the snow free channel to discharge, applicable for water surface elevations between 15.06 feet and 15.96 feet [Q = (WSE/15.115255756)^(1/0.01640881)]. The mean daily discharge was determined by applying this relationship to the 48 water surface elevation measurements made per day (30 minute intervals). The mean daily discharge was calculated as the average of these 48 discharge calculations.

Acre-ft = acre-feet

cfs = cubic feet per second

TABLE 3-15: SUMMARY OF MEDIAN MONTHLY FLOW ESTIMATES

Stream Name	Site[1]	Drainage Area[2] (sq. mi.)	Median Monthly Flow[3]			
			June (cfs)	July (cfs)	August (cfs)	September (cfs)
West Badami Creek	P2009-01	52.1	73	9.4	2.8	3.1
Middle Badami Creek	P2009-02	23.1	32	4.2	1.2	1.4
East Badami Creek	P2009-03	95.8	130	17	5.1	5.7
"O" Creek	P2009-04	5.6	7.8	1	0.3	0.3
"N" Creek	P2009-05	17.8	25	3.2	0.9	1.1
"M" Creek	P2009-06	4.2	5.9	0.8	0.2	0.3
No Name Drainage 1	PLX08	1.35	1.9	0.2	0.1	0.1
"L" Creek	P2009-07	39.1	55	7	2.1	2.3
"K" Creek	P2009-08	18.7	26	3.4	1	1.1
"J" Creek	P2009-09	2.2	3.1	0.4	0.1	0.1
"I" Creek	P2009-10	22.6	32	4.1	1.2	1.4
"G" Creek	P2009-11	16.7	23	3	0.9	1
"F" Creek	P2009-12	18.4	26	3.3	1	1.1
Creek 18a	P2009-13	0.9	1.3	0.2	0	0.1
Creek 18a	R2009-01	0.6	0.8	0.1	0	0
"E" Creek	P2009-14	9.9	14	1.8	0.5	0.6
"E" Creek	R2009-02	9.6	13	1.7	0.5	0.6
"D" Creek	P2009-15	8.5	12	1.5	0.5	0.5
"D" Creek	R2009-03	8.1	11	1.5	0.4	0.5
"C" Creek	P2009-16	1.8	2.5	0.3	0.1	0.1
"C" Creek	R2009-04	1.5	2.1	0.3	0.1	0.1
Creek 23	P2009-17	0.5	0.7	0.1	0	0
Creek 23	R2009-05	0.2	0.3	0	0	0
"B" Creek	P2009-18	2	2.8	0.4	0.1	0.1
"B" Creek	R2009-06	0.6	0.8	0.1	0	0
"B" Creek	R2009-07	0.2	0.3	0	0	0
"S" Creek	P2009-19	7.7	11	1.4	0.4	0.5
"S" Creek	R2009-08	6.3	8.8	1.1	0.3	0.4
"R" Creek	P2009-20	0.7	1	0.1	0	0
"A" Creek	R2009-09	2.4	3.4	0.4	0.1	0.1

Notes:
1 Site locations are shown on Figure 3-7.
2 Drainage areas were obtained from PND (2009a) except for No Name Drainage 1 which was obtained from Michael Baker Jr. Inc. 1998.
3 Median monthly flows were computed as the average of the average monthly unit runoff value for the Putuligayuk River and Nunavak Creek, two long-term USGS and University of Alaska Fairbanks stream monitoring stations.
cfs = cubic feet per second
sq. mi. = square miles

Lake Recharge

The natural recharge of fresh water lakes in the Project area is the result of snowmelt runoff and summer precipitation. The magnitude of the recharge to a particular lake is dependent upon the size of the lake's drainage basin, the amount of precipitation, the runoff characteristics of the drainage basin, the amount of evaporation from the lake surface, and the discharge characteristics of the lake outlet.

Because lakes provide a source of water for many oil field operations, including potable water and ice road construction, a concern has arisen as to whether more water is being withdrawn than can be replaced in a typical year. An evaluation of winter water use in the current oil field operating areas was undertaken by the University of Alaska, Water and Environmental Research Center (Hinzman et al. 2006) and found that under the current water use practices, "there were no measurable negative effects of winter pumping on the lakes studied".

The amount of water likely to be available to recharge the proposed water supply (new gravel mine) from "B" Creek during spring break-up was investigated in 2003 (URS 2003a). Flow during the 2003 spring break-up was monitored (URS 2003a), and data generated are presented on Figure 3-10 and in Table 3-14. Additionally, a set of regression equations where developed to estimate the volume of water that could be anticipated in any given year, with varying degrees of certainty (URS 2003b). The regression equations were developed from data associated with three long-term stream gage stations on the North Slope and use drainage area as the sole independent variable. Knowing the drainage area of the lake or mine site to be recharged, the regression equations can be used to estimate the volume of water likely to be available for recharge during spring break-up. A summary of the probability of various volumes of water being discharged from "B" Creek during spring break-up is presented in Table 3-16. Based on the information summarized in Table 3-16, there is a 50 percent chance that the spring break-up flood volume in any given year will be equal to or exceed 703 million gallons. There is a 90 percent chance that it will be equal to or exceed 210 million gallons. The regression equations used to prepare Table 3-16 (URS 2003b) are suitable for use in estimating the likely recharge volumes associated with lakes and mine sites within the coastal plain portions of this project. The equations can also be used to estimate the probability that projected water needs can be satisfied over a number of years, even when the water requirements vary from one year to the next.

TABLE 3-16: THE PROBABILITY OF VARIOUS MAGNITUDES OF SPRING BREAKUP FLOOD VOLUMES OCCURRING 0N "B" CREEK NEAR THE PROPOSED MATERIAL SITE IN ANY GIVEN YEAR

(COLUMN 1) Total Spring-Breakup Flood-Volume in Stream (Million Gallons)	Probability of Actual Volume in the Stream Exceeding[1] Column 1 (Percent)	Probability of Actual Volume in the Stream Being Less Than Column 1[2] (Percent)
86	99.99	0.01
113	99.95	0.05
134	99.90	0.10
150	99.80	0.20
181	99.50	0.50
210	99.00	1.00
304	95.00	5.00
372	90.00	10.00
471	80.00	20.00
703	50.00	50.00
1,810	1.00	99.00

Notes:
1 This is the probability of exceedance, which is the chance that the actual spring-break-up flood-volume in any given year will be greater than or equal to the volume stated in Column 1.
2 This is the probability of non-exceedance, which is the chance that the actual spring-break-up flood-volume in any given year will be less than the volume stated in Column 1.

Storm Surge Effects

Storm surge is a coastal flooding phenomenon caused by the piling up of seawater against the shore, as a result of wind stress and atmospheric pressure differences caused by a storm. Storm surge can cause salt water to enter, and the water surface elevation to rise, in the lower reaches of coastal rivers and streams. Overflow and spray from storm surge may also cause salt water to enter low-elevation lakes.

Based on data collected at the National Oceanic and Atmospheric Administration (NOAA) Tide Gage Station Number 9497645 (NOAA 2009) located in Prudhoe Bay, the annual maximum storm surge event is most likely to occur in July or August, but can occur any time between July and December. The results of a frequency analysis of the annual maximum water surface height above MSL is presented in Table 3-17.

TABLE 3-17: STORM SURGE HEIGHT

Return Period (years)	Height above Mean Sea Level (feet)
2	2.9
5	3.6–3.7
10	4.0–4.2
20	4.3–4.7
50	4.7–5.3
100	4.9–5.8

Notes:

Estimated heights are based on data for NOAA Tide Gage Number 9497645 located in Prudhoe Bay, Alaska.

The variation in the predicted height above mean sea level is because of the range in estimates produced by the different distributions used to fit the data.

The highest annual water surface elevation was selected for each of the 14 years of record and used in combination with each of four frequency distributions (normal, log-normal, log-Pearson Type III, and log-Pearson Type III with expected probability adjustment) to estimate the height of the storm surge above mean sea level associated with a specified average return period.

3.1.3.3 Water Quality

Water quality data for the project area are limited, but appear typical of fresh water resources across the North Slope, where most lakes contain high concentrations of calcium bicarbonate, are low in dissolved solids, have low alkalinity, have a pH that is near neutral, and have relatively low biological productivity compared to lakes in more temperate regions (Sloan 1987). Lakes near the coast can have higher concentrations of sodium chloride due to storm surge and windblown spray.

The water quality in North Slope lakes generally decreases throughout the winter. As ice forms, ions and impurities are driven out of ice crystals, and concentrate in the remaining free water under the ice. As the winter progresses, the concentration of ions increases and the dissolved oxygen (DO) concentration decreases in remaining free water. The magnitude of the increase in the chemical concentrations of these constituents will be approximately inversely proportional to the decrease in the volume of free water. In spring when the lakes thaw and runoff enters the lakes, the chemical concentrations of impurities are reduced while the DO concentrations increase.

On 27 September 2002, surface water quality samples were collected at 13 sites near the Point Thomson Unit (PTU) #3 gravel pad and proposed pad expansion area (URS 2002). The samples were collected from marine, estuarine, and fresh bodies of water to acquire physical and chemical data to support the National Pollutant Discharge Elimination System (NPDES) permit process associated with the Project, and to obtain background water quality data. The measured concentrations were compared to ADEC surface water quality standards (18 Alaska Administrative Code [AAC] 70), the ADEC drinking water standards (18 AAC 80) and EPA ambient water quality criteria. All of the measured concentrations were below the applicable water quality standards. No anomalous data were measured, and all results appear to provide a representative data set of background conditions in potential effluent receiving surface waters near the PTU #3 proposed pad expansion area (URS 2002). The locations at which samples were taken are shown on Figure 3-11, and a summary of the field parameter measurements is presented in Table 3-18. Summaries of the volatile, semivolatile, physical parameters, and inorganic analytical results can be found in Attachment C of the URS Technical Memorandum (URS 2002).

The Alaska Department of Natural Resources (ADNR), Office of Habitat Management and Permitting, conducted fish surveys and collected water quality data in selected streams within the Project area during 2002 and 2003 (Winters et al. 2004). The water quality parameters sampled included: temperature, specific conductance, pH, DO concentration, and DO percent saturation. In 2002, water quality data were collected at 24 sites, and in 2003 data were collected at 21 of the same sites and two new sites. In general the water quality observed was typical of North Slope coastal plain fresh waters. The pH of the waters was generally slightly alkaline, and the specific conductance values were indicative of fresh water. The specific conductance values were slightly higher in August 2002 than in July 2003, and were most likely the result of lower stream flows during the August sampling (Winters et al. 2004). A summary of the data collected is presented in Table 3-19.

In a study of water quality in both pumped and unpumped lakes, located between the Colville River Delta and the Sagavanirktok River, between September 2002 and August 2005, it was found that there were no measurable negative effects of winter pumping on the lakes studied (Hinzman et al. 2006). The physical and chemical parameters were similar between pumped and control lakes for the range of water use observed. In a similar study conducted between September 2005 and May 2007 (Blackburn et al. 2007), both lakes and reservoirs were studied. The results of the study (Blackburn et al. 2007) indicated that DO concentration decreased with depth, and temporally through the winter in all seven arctic lakes and reservoirs studied. However, the degree of oxygen depletion over the winter was influenced by differences in physical and chemical characteristics among the lakes and reservoirs. Differences in water-use practices among lakes and reservoirs caused little to no change in DO concentration over the winter. Both depth and dissolved organic carbon (DOC) concentration appear to be key factors that control winter DO depletion rate, with lake and reservoir depth influencing the initial volume of oxygen that is available for lake-biota over the winter, and DOC concentration in the sediments fueling consumption-rates of oxygen. Shallow lakes with high DOC concentrations appear to be particularly susceptible to low-oxygen conditions developing over the winter, whereas lakes greater than or equal to 3.5 meters in depth with low DOC concentration are best suited for water-use sources that also serve as over-wintering fish habitat for sensitive fish species.

TABLE 3-18: WATER QUALITY MEASUREMENTS MADE NEAR PTU#3 (URS 2002)

Water Sample Type	Sample Site ID	Sample Date	Latitude (N) (WGS 84) (decimal degrees)	Longitude (W) (WGS 84) (decimal degrees)	Conductivity µS/cm	Dissolved Oxygen mg/L	pH	Salinity percent	Salinity ppt	Temperature °C
Marine	PTU3-SW1	27-Sep-09	70.17270	146.25232	45,800	10.37	7.94	2.71	27.1	0.3
Marine	PTU3-SW2	27-Sep-09	70.16982	146.24993	46,100	10.67	7.94	2.73	27.3	0.1
Fresh	PTU3-SW3	27-Sep-09	70.16950	146.25200	1,010	13.27	6.88	0.03	0.3	0.3
Fresh	PTU3-SW4	27-Sep-09	70.16925	146.25557	543	2.14	6.81	0.02	0.2	0.5
Fresh	PTU3-SW5	27-Sep-09	70.16807	146.25447	865	12.11	8.17	0.03	0.3	0.4
Fresh	PTU3-SW6	27-Sep-09	70.16567	146.26765	580	10.42	7.6	0.02	0.2	1.1
Fresh	PTU3-SW7	27-Sep-09	70.16567	146.26765	488	12.16	8.13	0	0	0.9
Fresh	PTU3-SW8	27-Sep-09	70.16890	146.26410	624	5.02	7.11	0.02	0.2	1.2
Fresh	PTU3-SW9	27-Sep-09	70.16822	146.26533	370	7.8	6.95	0.01	0.1	1.5
Fresh	PTU3-SW10	27-Sep-09	70.16825	146.26530	765	0.14	7.04	0.03	0.3	1.5
Fresh	PTU3-SW11	27-Sep-09	70.16778	146.24783	5,610	10.55	7.93	0.6	6	0.6
Fresh	PTU3-SW12	27-Sep-09	70.16705	146.25022	3,830	10.27	7.95	0.16	1.6	0.7
Fresh	PTU3-SW13	27-Sep-09	70.16787	146.25887	970	11.83	8.24	0.03	0.3	0.9

Notes:
°C = degrees Celsius
ID = Identification
mg/L = milligrams per liter
ppt = parts per thousand
µS/cm = microsiemens per centimeter
WGS 84 = World Geodetic System 1984

TABLE 3-19: RIVER WATER QUALITY DATA COLLECTED IN RIVERS BY ALASKA DEPARTMENT OF FISH AND GAME

Name of Water Body	Sample Site ID	Sample Date	Latitude (N) (NAD 27)	Longitude (W) (NAD27)	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH	Temperature
			(decimal degrees)		µS/cm	mg/L	percent		°C
"A" Creek	A1	3-Aug-02	70.14051	146.11674	300.2	9.90	93.2	8.01	12.89
"A" Creek	A2	3-Aug-02	70.14055	146.11795	303.2	9.89	92.7	8.02	12.65
"A" Creek	A2	9-Jul-03	70.14055	146.17125	271.0	11.24	93.8	8.32	7.33
"A" Creek	A3	9-Jul-03	70.11150	146.11795	282.1	10.63	88.8	8.13	7.75
"B" Creek	B1	3-Aug-02	70.13532	146.25753	204.3	10.15	97.3	7.89	13.74
"B" Creek	B2	3-Aug-02	70.13591	146.25775	203.2	9.84	95.0	7.77	14.16
"B" Creek	B3	3-Aug-02	70.15259	146.24729	247.4	8.88	82.2	7.80	12.10
"B" Creek	B3	9-Jul-03	70.15259	146.24729	225.3	10.67	88.5	7.96	7.51
"B" Creek	B4	3-Aug-02	70.16076	146.24638	273.8	8.37	84.2	7.86	15.91
"B" Creek	B5	9-Jul-03	70.13351	146.25964	216.0	10.83	88.7	7.90	7.03
"B" Creek	Mine Site	3-Aug-02	70.13624	146.24476	295.9	10.52	97.1	8.05	11.90
"C" Creek	C1	3-Aug-02	70.16509	146.27980	251.2	9.79	96.2	8.15	14.80
"C" Creek	C2	3-Aug-02	70.16782	146.28763	257.0	8.76	88.5	7.64	16.17
"C" Creek	C2	9-Jul-03	70.16782	146.28763	198.3	11.02	92.3	7.93	7.92
"C" Creek	C3	9-Jul-03	70.16351	146.28133	200.3	11.28	94.7	8.07	8.00
"D" Creek	D1	3-Aug-02	70.16491	146.32660	230.5	9.39	94.6	8.05	16.01
"D" Creek	D1	9-Jul-03	70.16491	146.32660	198.8	10.45	88.5	7.80	8.43
"D" Creek	D2	3-Aug-02	70.17102	146.33125	245.1	8.69	89.5	7.59	17.09
"D" Creek	D2	9-Jul-03	70.17102	146.33125	205.7	10.94	92.1	7.80	8.81
"E" Creek	E1	3-Aug-02	70.16877	146.38566	303.6	9.03	87.7	7.62	14.37
"E" Creek	E1	11-Jul-03	70.16877	146.38566	223.1	8.89	81.3	7.66	11.72
"E" Creek	E2	3-Aug-02	70.17321	146.37754	301.0	9.48	89.3	7.85	12.55
"E" Creek	E2	11-Jul-03	70.17321	146.37754	225.7	9.10	85.0	8.00	12.12
"F" Creek	F1	3-Aug-02	70.16168	146.43918	293.7	8.65	88.5	7.83	16.72

Name of Water Body	Sample Site ID	Sample Date	Latitude (N) (NAD 27)	Longitude (W) (NAD 27)	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH	Temperature
			(decimal degrees)		µS/cm	mg/L	percent		°C
"F" Creek	F1	11-Jul-03	70.16168	146.43918	284.0	8.96	83.0	7.91	12.20
"F" Creek	F2	3-Aug-02	70.17173	146.44643	298.8	8.23	84.6	7.80	16.89
"F" Creek	F2	11-Jul-03	70.17173	146.44643	296.8	9.10	83.8	7.88	11.90
"G" Creek	G1	3-Aug-02	70.17464	146.50172	287.6	8.66	89.0	7.93	16.98
"G" Creek	G1	11-Jul-03	70.17464	146.50172	232.1	10.13	95.7	8.23	13.01
"H" Creek	H1	7-Aug-02	70.16697	146.53970	241.9	10.21	81.3	7.35	5.61
"H" Creek	H1	11-Jul-03	70.16697	146.53970	129.7	9.50	87.6	7.62	12.20
"I" Creek	I1	7-Aug-02	70.16277	146.59185	278.6	11.61	94.4	7.84	6.31
"I" Creek	I1	11-Jul-03	70.16277	146.59185	216.6	9.96	93.0	7.95	12.56
"J" Creek	J1	7-Aug-02	70.15994	146.63157	265.8	11.72	94.2	7.83	5.94
"J" Creek	J1	11-Jul-03	70.15994	146.63157	231.8	10.44	96.4	7.98	12.22
"K" Creek	K1	7-Aug-02	70.15552	146.69080	304.7	11.62	94.3	7.73	6.26
"K" Creek	K1	13-Jul-03	70.15552	146.69080	281.3	10.61	91.0	7.89	8.88
"L" Creek	L1	7-Aug-02	70.15164	146.75691	283.6	11.02	90.5	7.91	6.75
"L" Creek	L1	13-Jul-03	70.15164	146.75691	255.6	10.53	90.0	8.07	8.91
"M" Creek	M1	7-Aug-02	70.14583	146.83076	275.7	11.78	94.5	7.70	5.84
"M" Creek	M1	13-Jul-03	70.14583	146.83076	228.4	9.85	85.0	7.82	9.16
"N" Creek	N1	7-Aug-02	70.14130	146.86477	254.2	11.74	96.2	7.90	6.63
"N" Creek	N1	13-Jul-03	70.14130	146.86477	233.8	10.31	89.8	8.02	9.56
"O" Creek	O1	7-Aug-02	70.13793	146.93698	231.6	11.10	91.2	7.63	6.79
"O" Creek	O1	13-Jul-03	70.13793	146.93698	170.4	10.16	89.5	7.93	10.03
"R" Creek	R1	13-Jul-03	70.15069	146.15915	215.6	11.93	98.0	8.15	7.12
"S" Creek	S1	13-Jul-03	70.15665	146.20552	227.1	10.80	88.4	7.80	6.89

Notes:
°C = degrees Celsius
ID = Identification
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
NAD 27 = North American Datum 1927
ppt = parts per thousand

The University of Alaska, Water and Environmental Research Center, has measured water quality at the end of winter in lakes along the coastal plain between the Sagavanirktok River and the Canning River in 2006, 2007, and 2008 (White et al. 2006; Myerchin et al. 2007, 2008). A summary of the data that have been collected is presented in Table 3-20. The locations of the lakes are shown on Figure 3-8. The data indicate that the Badami and Shaviovik gravel mine sites consistently maintained high DO levels through all or most of the water column. Neither mine site had high salinity levels. The data also indicated that little mid- to late-winter water is available in the six natural lakes sampled. DO concentration was less in the lakes than the reservoirs, usually significantly less than half of what it was in the reservoirs. Salinity was higher in the lakes than the reservoirs.

TABLE 3-20: UNDER ICE WATER QUALITY MEASUREMENTS (UNIVERSITY OF ALASKA 2006, 2007, 2008)

Lake ID	Date	Total Depth Below Water Surface (ft)	Sample Depth Below Water Surface (ft)	Depth Below Bottom of Ice (ft)	Temperature °C	pH	Oxygen-Reduction Potential (mV)	Dissolved Oxygen		Actual Conductivity (µS/cm)	Specific Conductance at 25°C (µS/cm)
								(mg/L)	(%)		
Badami Pit	30-Apr-06	28.1	6	0.1	0.20	7.54	114.5	16.38		136	270
			7	1.1	0.20	7.52	116.0	16.60		137	272
			8	2.1	0.05	7.49	119.3	16.76		137	273
			10	4.1	0.02	7.52	116.2	16.75		142	284
			12	6.1	0.03	7.56	117.9	17.03		144	288
			14	8.1	0.04	7.48	118.3	16.60		161	321
		12:28	16	10.1	0.11	7.46	121.2	16.66		163	337
			18	12.1	0.21	7.44	122.9	16.24		188	373
			20	14.1	0.22	7.43	122.8	15.97		189	375
			22	16.1	0.22	7.39	124.4	16.10		191	379
			24	18.1	0.23	7.39	126.3	15.94		193	382
			25	19.1	0.23	7.45	123.8	15.28		194	384
			26	20.1	0.23	7.43	125.2	15.62		194	384
			27	21.1	0.24	7.42	125.5	15.67		195	386
			28	22.1	0.24	7.43	126.5	15.72		197	390
			Bottom	22.2	0.24	7.37	127.8	15.44		199	394
Badami Pit	8-May-07	12.34	7	0.04	0.71	7.66	-12.6	15.99		209	390
			8	1.04	0.72	7.65	-30.4	14.62		209	390
			10	3.04	0.72	7.63	-23.5	14.85		209	390
			11	4.04	0.72	7.65	-13.5	14.63		209	391
			12	5.04	0.72	7.63	-4.4	14.68		210	391

Lake ID	Date	Total Depth Below Water Surface (ft)	Sample Depth Below Water Surface (ft)	Depth Below Bottom of Ice (ft)	Temperature °C	pH	Oxygen-Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Actual Conductivity (µS/cm)	Specific Conductance at 25°C (µS/cm)
Badami Pit	16-May-08	17.97	6	0.1	0.58	6.63	147.7	16.36	113.7		
			7	1.1	0.91	6.75	136.6	16.53	119.0		
			8	2.1	1.65	7.06	120.1	15.77	113.2		
			9	3.1	2.00	7.26	109.1	18.32	132.6		
			11	5.1	2.26	7.33	105.3	18.57	136.3		
			13	7.1	2.40	7.39	103.5	18.04	132.2		
			15	9.1	2.47	7.44	102.1	17.06	125.4		
			16	10.1	2.45	7.47	101.4	16.72	122.5		
			17	11.1	2.43	7.50	93.0	15.96	117.1		
			Bottom	12.07	2.43	7.52	90.7	15.36	112.5		
Shaviovik Pit	3-May-06	32.9	5	0.12	0.14	6.67	80.8	17.74		181	360
			6	1.12	0.08	6.72	80.9	17.46		180	359
			7	2.12	0.09	6.72	82.6	17.17		180	359
			9	4.12	0.15	6.80	86.0	16.96		179	356
			11	6.12	0.17	6.81	87.4	16.85		179	356
			13	8.12	0.18	6.83	85.8	16.86		179	355
			15	10.12	0.18	6.85	86.5	16.80		179	355
			20	15.12	0.27	6.92	84.5	16.61		179	354
			25	20.12	0.45	6.95	84.2	14.35		178	350
			26	21.12	0.47	6.96	88.4	14.23		179	351
			27	22.12	0.47	6.94	89.0	13.26		179	351
			28	23.12	0.49	6.98	94.8	7.41		179	351
			30	25.12	0.48	6.78	101.2	3.66		186	365
			31	26.12	0.47	6.80	102.7	0.76		208	408
			32	27.12	0.46	6.74	----	0.44		248	487

Lake ID	Date	Total Depth Below Water Surface (ft)	Sample Depth Below Water Surface (ft)	Depth Below Bottom of Ice (ft)	Temperature °C	pH	Oxygen-Reduction Potential (mV)	Dissolved Oxygen		Actual Conductivity (µS/cm)	Specific Conductance at 25°C (µS/cm)
								(mg/L)	(%)		
Shaviovik Pit	8-May-07	16.47	6	1.02	0.21	7.73	-10.7	16.71		184	349
			7	2.02	0.29	7.91	-48.1	16.03		184	348
			9	4.02	0.35	7.87	-40.9	15.49		183	347
			11	6.02	0.36	7.83	-35.9	15.55		184	347
			13	8.02	0.36	7.96	-40.0	15.45		184	347
			15	10.02	0.36	7.68	-7.0	15.23		183	346
			16	11.02	0.37	7.58	-30.0	16.01		183	345
			Bottom	11.49	0.37	9.20	-57.3	15.87		183	345
Shaviovik Pit	16-May-08	13.93	6	0.03	0.65	7.39	112.0	19.91	140.0		
			7	1.03	0.78	7.38	48.2	18.90	133.0		
			8	2.03	1.35	7.56	16.7	18.10	129.7		
			9	3.03	1.79	7.63	-21.6	17.78	128.2		
			10	4.03	1.90	7.66	-38.5	18.02	130.6		
			11	5.03	1.91	7.66	-117.4	16.92	122.5		
			12	6.03	1.92	7.65	-89.7	16.11	116.6		
			13	7.03	1.92	7.65	-63.4	15.25	110.5		
			Bottom	7.96	1.93	7.61	-70.4	16.36	118.7		
W0609	2-May-06	5.9	4.5	0.12	0.03	6.88	87.0	1.87		1,095	2,187
			5	0.62	-0.02	6.90	79.7	1.68		1,091	2,184
			5.5	1.12	-0.02	6.92	72.5	1.55		1,090	2,182
W0706	9-May-07	7.51	5.5	0.39	0.39	7.08	84.9	7.91		352	663
			6	0.89	0.55	7.20	7.7	6.87		353	662
			6.5	1.39	0.82	7.25	-0.9	6.32		355	659
			Bottom	2.4		7.12	22.7	6.39		356	661

Lake ID	Date	Total Depth Below Water Surface (ft)	Sample Depth Below Water Surface (ft)	Depth Below Bottom of Ice (ft)	Temperature °C	pH	Oxygen-Reduction Potential (mV)	Dissolved Oxygen		Actual Conductivity (µS/cm)	Specific Conductance at 25°C (µS/cm)
								(mg/L)	(%)		
W0707	8-May-07	5.51	5	0.34	0.16	7.00	-19.3	0.71		590	1,122
			Bottom	0.85	0.10	6.96	-23.2	0.63		590	1,122
W0708	8-May-07	5.74	5	0.27	0.27	7.12	-54.5	4.40		465	882
			Bottom	1.01	0.20	7.01	-52.5	4.88		468	889
W0709	8-May-07	6.63	5.5	0.35	0.11	7.32	-96.2	3.33		550	1048
			6	0.85	0.05	7.23	-26.2	2.61		548	1047
			Bottom	1.48	0.04	7.23	-37.7	2.59		551	1054
W0710	4-May-07	6.6	5.5	0.48	0.64	7.06	111.8	5.87[1]		288[1]	538[1]
			6	0.98	0.53	7.04	107.2	5.67[1]		289[1]	542[1]
			6.5	1.48	0.74	7.00	106.7	4.78[1]		290[1]	546[1]

Notes:
[1] Pre-sampling calibration check passed, but post-calibration check failed.
°C = degrees Celsius
ft = feet
ID = Identification
µS/cm = microsiemens per centimeter
mg/L = milligrams per liter
mV = millivolt

3.1.4 Physical Oceanography and Coastal Water Resources

3.1.4.1 Oceanography of Lion Bay

Lion Bay, formerly known as Lion Lagoon, is located directly offshore of Point Thomson and about 46 miles (74 kilometers) east of Prudhoe Bay. Flaxman Island and a chain of barrier islands, known as the Maguire Islands (including Challenge, Alaska, Duchess, and Northstar islands), form the bay. The Beaufort Sea lies seaward of these islands (Figure 3-12). Lion Bay is approximately 3–4 miles (5–6 kilometers) long, with water depths typically 5–13 feet (1.5–4 meters). Passes or gaps between the barrier islands serve to connect the bay waters with the Beaufort Sea and thus waves, storm surges, and other regional oceanographic processes influence the bay waters.

3.1.4.2 Bathymetry

The barrier islands serve to shelter or partially protect much of the bay from exposure to storm waves in the Beaufort Sea during the open water periods. The Mary Sachs Entrance is a broad, 2-mile (3-kilometer) pass between Northstar and Flaxman Islands (Figure 3-12). The bay east of the Mary Sachs Entrance is quite shallow and protected by Flaxman Island, while west of the Mary Sachs Entrance the bay is deeper, wider, and open at the west end.

Water depth in the eastern part of the bay is quite shallow. Shoals are common near the mouth of the Staines River and the 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 feet [366 meters]) and relatively deep (26 feet [8 meters]). Historical soundings obtained from NOAA Chart No. 16045, revised in 1996, suggest the bay 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 bay gently increase towards the west to a depth of 8 feet (2.4 meters) approximately mid-length of Flaxman Island and reach 11 feet (3.4 meters) immediately northeast of the shoreline.

Mary Sachs Entrance is a relatively deep pass, with a northeast/southwest-oriented channel that extends toward the Project. Water depths within the channel are typically 9–11 feet (2.7–3.4 meters) with the 10-foot (3-meter) isobath approximately 2,400 feet (732 meters) north of the mainland shore in the vicinity of the Project. Mary Sachs Entrance provides a break in the protection offered by the barrier islands, exposing the shoreline east of the Central Pad and further east 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 bay is protected by the Maguire Islands. This portion of the bay widens from 1.5 miles (2.4 kilometers) at Point Thomson to 3.5 miles (5.6 kilometers) near Challenge Island. Water depths adjacent to the mainland between Point Thomson and Point Hobson are typically 7–10 feet (2–3 meters) and gently increase to 16 feet (5 meters) at the west end of the bay.

3.1.4.3 Physical Oceanography

Several oceanographic studies have been conducted in Lion Bay (Kinnetic Laboratories, Inc. 1983; Tekmarine 1983; URS 1999). Understanding of the bay dynamics and relation to the adjacent Beaufort Sea is augmented substantially by extensive work done along the Beaufort Sea coast since 1976, synthesized by Colonell and Niedoroda (1990). The hydrography (temperature, salinity, and water column structure) of summer Beaufort Sea coastal waters is determined by the 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 nearshore, while westerly winds raise sea level and initiate regional down-welling. Local salinity is a function of 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 Lion Bay are provided in the following sections.

Tides and Storm Surges

As with other areas along the Beaufort Sea coast, astronomical tidal ranges are only about 8 inches (20 centimeters); however, the range of sea level rise and fall because of major storms (storm surges) can be considerably higher. A NOAA tidal station has been operating in Prudhoe Bay since 1993 and has demonstrated the following tidal characteristics:

- Mean Higher High Water (average of the highest of approximately two tides per day) of 0.69 foot (21 centimeters);
- Mean Lower Low Water (MLLW) of 0.00 foot (reference datum); and
- Mean Tide Level of 0.33 foot (10 centimeters). NOAA occupied a tidal station on Flaxman Island for one month during 1987 and found the tidal signal to be essentially the same as at Prudhoe Bay which allows the longer term record to serve as a proxy for the Project area.

Storm surges result from the combined effects of wind and atmospheric pressure changes with winds having the greater effect. The shallow shelf waters are responsible for allowing surges to develop. Storm surges also usually include the wave set-up, because they generally occur simultaneously. Wave set-up is an increase in water level within the wave-breaking zone because of the physics of breaking waves. The set-up can increase the water elevation by about 15 percent of the offshore significant wave height (the significant wave height is defined below). Positive surges (water level increases) are associated with westerly winds, and negative surges (water level decreases) are associated with easterly winds.

Tide gages often record not only the astronomical tides but the actual water level, which can be a combination of tides, atmospheric pressure, wind stress, and wave set-up. The Prudhoe Bay recorder is located on the east side of West Dock Causeway and therefore does not capture the wave set-up because of storms from the west. Extremal analyses of the Prudhoe Bay tide data found that at the 90 percent confidence level, the 100-year storm surge is 6.0 feet (1.8 meters) (PND 2009b).

A Kinnetic Laboratories, Inc. study (1983) observed a maximum positive surge of 2 feet (61 centimeters) in Lion Bay associated with winds up to 35 knots (65 kilometers per hour [km/hr]) during an ice-covered period in October. Clearly, this value does not represent the design condition within the project area. Reimnitz and Maurer (1978) studied driftwood elevations left by a large gale-force westerly storm in the region in 1970 that had flooded some low-lying inland areas. They estimated the height of the surge in Lion Bay to be about 7–9 feet (2.1–2.7 meters) and projected this incident to have a recurrence interval of about 100 years. Debris line analyses have produced higher surge estimates, but they include wave set-up and wave run-up as well and would be expected to be higher, particularly if the ground is frozen. The Canadian Beaufort Sea is known to have positive storm surges of up to 6 feet (1.8 meters) and negative surges of 3 feet (0.9 meter).

Given the similarity in the tidal record at Prudhoe Bay and the much shorter NOAA record for Flaxman Island, it seems appropriate to use a 100-year storm surge at the project site as 6.0 feet (1.8 meters).

Waves

Storm waves are generated by wind stress on the water surface. The wind velocity, the duration of the wind and the fetch (the extent of open water across which the wind blows) influence wave height and period (Bascom 1980). Another important factor that influences wave height is water depth. As waves move into shallow waters, breakers form and dissipate the wave energy. This shoaling causes wave heights to increase.

On the gently sloping Beaufort Sea shelf, the waves begin to break when the wave height reaches about 80 percent or less of the water depth. In shallow lagoon waters such as Lion Bay, wave heights are expected to be less than storm waves generated in the deeper Beaufort Sea waters seaward of the barrier islands, because of the sheltering provided by the islands. For waves generated from winds with a strong onshore component, a limited amount of wave energy is allowed through the inter-island passes. Spit formation along the shoreline is evidence that some energy is admitted through the passes and energy coming through Mary Sachs Entrance may be responsible for the spit formation near Central Pad, which is located on an exposed portion of the shoreline immediately south of the Mary Sachs Entrance.

Wave refraction is also important in determining the wave energy at the shoreline. Refraction is the change in wave energy caused by the bending of the wave rays (lines drawn perpendicular to the wave crest). Along uniform shorelines, the waves approaching the shoreline at an angle to the bottom contours are refracted such that they lose energy per unit of cross-sectional area perpendicular to the wave ray. That is, the distance between adjacent wave rays increases. The process is so effective at reducing the energy that by turning 90 degrees nearly all of the energy is lost. The actual loss at any shore location is a function of the angle, the beach slope, and the orientation of the bottom contours. Normally, refraction causes a reduction in wave energy. However, under rare conditions when waves approach headlands at certain angles, the wave energy can actually increase.

Waves from directly offshore are sheltered from much of the Project area by the barrier islands, except for the Central Pad, but waves can also approach the Project site from the east and west. These directions are essentially aligned parallel to the shoreline and have large fetches. However, to reach shore, they must undergo refraction in the shallow waters near shore, greatly reducing their shore-directed energy. Winds with both onshore and longshore components may, in certain cases, generate the highest wave to strike the beach.

Using moored instruments, Kinnetic Laboratories, Inc. (1983) measured wave conditions in Lion Bay. During the study, waves were found to be relatively small in the lagoon because of a lack of significant strong wind events and the lingering presence of sea ice. The maximum wave heights were generally less than 2–3 feet (60–90 centimeters). Significant wave heights (defined as the average of the highest one-third of the waves) were measured at just over 1 foot (30 centimeters), with significant periods of about 2.5 seconds. One storm event during August 1982 with winds over 20 knots (37 km/hr) produced waves up to 5 feet (1.5 meters), significant wave heights of 2.75 feet (84 centimeters), and periods up to 3.5 seconds.

A joint industry project (JIP) has modeled wave conditions in the Beaufort Sea since 2005 (Oceanweather 2005a, 2005b, 2006, 2008; PND 2009b). This Project developed winds from historical meteorological data and used it to hindcast wave climates. While locations between the barrier islands and the Project site were included in that report, their values at those locations did not account for the presence of the islands and were therefore not characteristic of the area.

More site-specific modeling was done for the PND report that transformed the offshore BORE waves through openings between the islands and around their ends to provide waves directly offshore of the Project area. The values presented in the report were for design storm conditions that included maximum winds and storm surge water levels. It found that the offshore wave conditions were depth-dependent and that the significant wave heights were about one-half the breaking water depth (the depth of the water where the waves are breaking, which is a function of the deep-water wave height, wave period and bottom slope). The maximum waves that could be generated at the West and Central pads were attributable to storm winds from the west and north, respectively, while the more protected East Pad received the most severe waves as a result of storms from the east. Because winds from the west and north elevate the water level surges, the West and Central pads are subject to higher waves than the East Pad. Also, the larger waves were generated over long fetches, while the East Pad waves were generated over shorter fetches within the barrier island lagoon system. The longer fetches from the west and north generate waves with longer wave lengths that tend to break further offshore. For the depths and slopes found off the Project site, the waves are truly depth-limited. Therefore, the maximum breaking wave heights for the three sites were found to be 4.3, 5.6, and 5.2 feet (1.3, 1.7, and 1.6 meter) for the West, Central, and East pads, respectively.

The water level used as input into these modeled results only included the tide and added storm surge as derived from the Prudhoe Bay gage. As was discussed, these did not include the additional depth associated with wave set-up. The model used to transform these storm waves into shallow water had the capacity to calculate this set-up and apply it to the wave conditions.

Currents

The nearshore Beaufort Sea has been studied for more than three decades; and although the oceanographic behavior of the open water environment is well understood, questions about the driving mechanisms for under ice currents remain. As with most shallow seas, the wind governs the hydrodynamics (water movement) of the Beaufort Sea almost exclusively during the open water period so 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 (Weingartner et al. 2005). MMS (2005) found that in the nearshore Alaska Beaufort Sea, currents often exceeded 0.4 knots (0.74 km/hr) during the open water period and were less than 0.2 knots (0.37 km/hr) beneath the ice.

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 inches [<20 centimeters]) with associated weak currents (<0.1 knot [0.18 km/hr) (Weingartner 2005), except in the narrow passes between barrier islands. The tidal currents display essentially the same signal during summer or winter. Winds are typically parallel to the coast, with easterlies (i.e., winds from the east) prevailing about 60 percent 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 knot (<30 centimeters per second [cm/sec]); however, at the peak of a severe easterly storm during late August, current speeds were nearly 0.97 knot (50 cm/sec). Tidal currents observed in the Mary Sachs Entrance were typically 0.014 to 0.19 knot (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 knots (2.2 km/hr) with a maximum recorded value of 1.7 knots (3.1 km/hr); 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).

Because actual current measurements in Lion Bay are limited to the entrances, winds must be used to estimate the inter-bay currents. The bay is shallow and the currents can probably be estimated as 2–4 percent of the wind speed. A wind speed of 30 knots (55 km/hr) probably produces surface currents of 0.6–1.2 knots (1.1 to 2.2 km/hr). These currents would be expected to decrease with depth.

River Input

The Canning and Staines rivers provide freshwater input to the Beaufort Sea in the vicinity of Point Thomson. 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 miles (188 kilometers) long and has a drainage area of about 2,256 square miles (5,843 square kilometers [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 cfs (31.86 cubic meters per second [m^3/sec]) (AEIDC 1974). Large coastal rivers such as the Canning show no measurable discharge from January–early May (MMS 1996). By contrast, the Staines River has an annual average flow of 14 cfs (0.40 m^3/sec) (AEIDC 1974). This river is 21 miles (34 kilometers) long and has a drainage area of about 28 square miles (73 km^2). The nearshore salinity is most affected by runoff from the Canning River and other streams during the summer/fall (open water) period.

Sea Ice

In late winter, first-year sea ice in the Beaufort Sea generally is about 6.5 feet (2 meters) thick. From the shore to a depth of about 7 feet (2.1 meters) 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 pile-ups 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 feet [30.5 meters]) in a phenomenon known as *ivu* by the Inupiaq inhabitants of the region.

Sea ice forms within Lion Bay 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 that grows to a thickness of about 7 feet (2.1 meters) by April or May. Ice blocks and ridges within the sheet may extend to 15 feet (4.6 meters) or more below the surface.

Ice movement during freeze-up is more common than later in the year when the near-shore ice becomes thicker and land-fast, or bottom-fast. Little data exists for the Project area to indicate that ice movement either as pile-up or ride-up is important. It is likely that the barrier islands may protect the lagoon from ice movement that is common on more exposed coastlines, but there is too little understanding as to why these movements occur to suggest that the Project area is more or less susceptible to ice movements.

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 break-up 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.

Break-up of the sea ice usually occurs by June or July. As melting continues, most of the sea ice retreats from shore with the multi-year 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-foot (10-meter) 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.

For the last several years, the Alaska Arctic has seen a greater reduction of the ice cover from the nearshore waters during the summer and fall than was previously normal, essentially extending the open water season by several weeks.

Coastal Erosion

Coastal erosion on the North Slope of Alaska is unique in comparison to beach erosion at lower latitudes. The important differences are that the shorelines are protected from waves for more than nine months of the year and that the ground is completely frozen during the entire year, except for a thin active layer that develops over the land during the summer and early fall.

The land is composed mostly of ice-wedge polygons, consisting of ice and soil, whose dimensions are typically a few tens of feet with some well in excess of 100 feet (30.5 meters). Each block is attached to its neighbor via ice wedges. The bond is quite strong until the ice melts. In the summer, the depth of this melting is at least as thick as the active layer and perhaps deeper as the melted wedges provide a pathway for water flow. The shoreline, over much of the area, constitutes the sea-facing section of these polygons at the waterline.

During the early part of the open water season with the dominant winds from the east and northeast, sea level remains at normal or below normal levels and breaking waves do not normally reach the base of these exposed polygons that make up the bulk of the shoreline. The only erosion is the gradual melting—enhanced by wind and rain—from the face of the vertical polygons or on remnants of polygons that have been previously dislodged. Some of these remnants may have fallen into the water and are left to melt and decompose in place.

Later in the season, the winds become more westerly and water levels increase in response—in some cases rising several feet. This exposes the seaward-facing shore polygons to waves which undercut them and eventually causing them to collapse into the water or onto the shore. There it is susceptible to further erosion from water and waves.

These polygons consist largely of ice crystals and very-fine-grained sediment with a large amount of organic material; they contain very little sand or gravel. As the collapsed polygon melts at an increasing rate, much of the organics float away and the finer-grained inorganics become suspended in the water and are carried offshore. Only a small amount of sand and larger materials are left behind to form a stable beach. All of the material left behind can be moved quite easily by waves that develop in Lion Bay.

In lower latitudes, exposed beaches go through a normal cycle where winter storms reduce the size of the beach and move the beach material offshore to form bars. In the summer, that material is gradually moved back onshore to enlarge the beaches, often with only a small net loss of material. However, over much of the North Slope—and in the Project area in particular—the situation is unlike lower latitude shorelines. While there may be some natural regeneration of beach material by waves from offshore, it is likely to be small and the net sediment transport direction is clearly offshore with the small amounts of sand and gravel found in the ice-rich bluffs forming narrow beaches and spits, and perhaps even barrier islands if the quantity of coarser material is sufficient.

Little changes on the beaches during the winter. Occasional ivus, or lesser ice pushes, may move sediment onto the shore, and sediment that has been incorporated into the ice as it freezes may be deposited on the shoreline as the ice melts in place. An unknown quantity of sediment is also taken from the beach by ice that is transported along the coast or offshore before melting. Given that erosion produces a net loss of beach material, the presence of ice during the long winter period serves to effectively mitigate erosion.

The beaches within the Project area are typical of this type of beach evolution. The Staines River mouth, just over 8 miles (12.9 kilometers) to the east of the Central Pad, probably has little or no effect on the beaches in the Project area. The offshore barrier island, however, provides a substantial protection from waves and increases the longevity of the shoreline in the Project area.

Analysis of aerial photography dating back to 1955 has been used to calculate erosion rates within the Project area particularly at the three pad sites (PND 2009). This analysis has shown the following average annual erosion rates:

- West Pad: -4.1 feet/year (1.3 meters/year),
- Central Pad: -1.2 feet/year (0.37 meters/year), and
- East Pad: -2.0 feet/year (0.61 meters/year).

These values are relatively low for the North Slope in general, probably due to the protection afforded by the barrier islands. In addition to these average erosion rates, the following maximum annual erosion rates over shorter periods of time were also calculated:

- West Pad: -14.8 feet/year (4.5 meters/year),
- Central Pad: -6.3 feet/year (1.9 meters/year), and
- East Pad: -5.3 feet/year (1.6 meters/year).

The PND report did not indicate when these higher rates occurred within the larger time period analyzed. Given the nature of polygon erosion processes it is likely that erosion rates are not uniform.

A review of early charts dating back to the early 1900s, while not geo-referenced, suggests that the shoreline shape inside the barrier islands was similar to that which exists today (PND 2009). Since at least 2007, there has been accelerated ice-melting in the Arctic and there have been claims of accelerated erosion. Such claims seem to be a reasonable response to longer and warmer open water periods presume to be occurring.

Water Quality

Salinity and Temperature

Marine waters are generally cold (30–37°F [-1–+3°C]) and saline (salinity of 27–32 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 freshwater discharge by coastal river systems, and the presence of sea ice.

Summer Conditions (Open Water)

The open water season typically starts in late June–early July and, as warming continues into summer, the sea-ice melts, resulting in about 75 days of open water; the days of open water have been increasing, but vary from year to year. After sea ice break-up, 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 (less than 1 foot [30 centimeters]) astronomical tide and occasional storm surges.

During and immediately after sea ice break-up, there is a freshwater surface layer (salinity of approximately 3–6 ppt) up to 13 feet (4 meters) thick that encompasses the lagoon and covers the marine (salinity of approximately 30 ppt) waters. This two-layer or stratified water column is a short-term event, persisting on average for only one or two weeks. As the sea ice diminishes, winds mix the waters of Lion Bay, creating an unstratified (uniform) water column of brackish (salinity of approximately 2–17 ppt) waters. As summer progresses, the water column typically remains unstratified, with salinity gradually increasing to marine conditions (salinity greater than 30 ppt) 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 Lion Bay, 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 Lion Bay. The other freshwater source is the Staines River, located immediately south of Brownlow Point; this river discharges within Lion Bay. Freshwater input from the Staines River is small, but still 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 Lion Bay. The Sagavanirktok River delta, located approximately 40 miles (64 kilometers) west of Lion Bay, 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 to hug the shoreline, with the difference between surface and bottom salinity decreasing towards Lion Bay.

Upwelling of marine bottom waters creates a stratified water column. 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 surface waters (salinity of approximately 24 ppt) and a bottom layer of cold, saline waters (salinity greater than 30 ppt) (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 can be completed by the end of October, with ice growing to a maximum thickness of 7.5 feet (2.3 meters) by April (MMS 1996). Ice cover has historically persisted on average for 290 days, until spring warming results in river break-up 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 observed during ice-covered conditions is less than 0.06 knots (3 cm/sec) (Berry and Colonell 1985).

While the current meters employed during under-ice studies are generally insensitive to speeds below 0.04 knots (2 cm/sec), 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 0.04 knots [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 1985).

Dissolved Oxygen

During the open water season, dissolved oxygen levels in Lion Bay are usually high, typically above 10 milligrams per liter (mg/L) (URS 1998). Under winter ice-cover, respiration by plankton and other organisms continues, but atmospheric exchange and photosynthetic production of oxygen cease. Throughout the ice-covered period, DO concentrations in areas with unrestricted circulation seldom drop below 6 mg/L. Under-ice DO concentrations of 7.4–13.2 mg/L were measured in Foggy Island Bay, which is immediately west of Lion Bay (Montgomery Watson 1997, 1998).

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 feet (5 meters) 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 from 1–173 nephelometric turbidity units (NTU). There was no correlation between TSS and turbidity values from samples collected within Lion Bay (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 2.5–76.5 mg/L (Montgomery Watson 1997, 1998). Field-measured turbidity for February and March under-ice conditions ranged from 1–35.6 NTU, and laboratory-measured turbidity ranged from 0–24 NTU (Montgomery Watson 1997, 1998).

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. Because 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 0.015–0.020 mg/L (URS 1998).

Hydrocarbons

Background water hydrocarbon concentrations in the Beaufort Sea tend to be low, generally less than 1 part per billion (ppb) and appear to be biogenic. Sediment aliphatic and aromatic hydrocarbon levels are relatively high in comparison with other undeveloped OCS 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 5–41 ppt dry weight. Most of these are higher-molecular-weight alkanes (n-C21 – n-C34) which are characterized by odd-carbon dominance, indicating a biogenic source from terrestrial plant materials. The presence of lower-molecular-weight alkanes (0.3–1.2 parts per million [ppm]) also suggests widespread presence of naturally occurring petroleum hydrocarbons in the sediments (MMS 1996).

3.1.5 Climate

3.1.5.1 Arctic Climate Variability before the 20th Century

The Arctic has experienced climatic conditions that have ranged from one extreme to the other over a period of millions of years. On the basis of the fossil record, 120–90 million years ago, during the mid-Cretaceous Period, the Arctic was significantly warmer than at present. Arctic geography, atmospheric composition, ocean currents, and other factors were also quite different. In contrast, as recently as 20,000 years ago, the Arctic was in the grip of intense cold and continental-scale glaciation. This was the last of a series of major glacial events and intervening warm periods that have characterized the past two million years of Arctic environmental history (Symon et al. [eds.] 2005). In particular, the most recent 20,000-year period is now thought to have been highly unstable and prone to rapid changes, especially temperature changes, which at times have occurred within a few decades or less (Symon et al. [eds.] 2005). In summary, the Arctic has experienced significant natural climate variability over the past two million years.

3.1.5.2 Arctic Climate Trends in the 20th Century

The Arctic climate is undergoing changes because of the combined effects of natural cyclical variations in weather patterns, including the Arctic and North Atlantic Oscillations (AO/NAO) (Thompson and Wallace 1998) and the Pacific Decadal Oscillation (PDO) (Mantua et al. 1997), and global climate change. The AO alternates between positive and negative phases, influencing the Arctic and Northern Hemisphere weather patterns. Since 1989, the AO has been in a positive phase, causing lower-than-normal arctic air pressure, stronger westerly winds, and higher-than-normal temperatures. Since 1976, the PDO has been largely in a positive phase. During positive PDO index events, westerly winds in the Northern Pacific are stronger, thereby causing increased southerly flow and warm air advection into Alaska during winter resulting in warmer than normal temperatures. Major PDO phases have persisted for 20 to 30 years (Mantua et al. 1997). It is not known to what extent global climate change may affect AO/NAO variability patterns. Observations of the AO/NAO patterns in the second half of the 20th century have not reflected changes predicted by models that incorporate changes in greenhouse gas (GHG) concentrations (Fyfe 2003).

Establishing climatic trends in the Arctic is challenging because of the small number of monitoring stations and relatively short record of data. Data are available from land-based meteorological stations, drifting stations, and drifting buoys. The data from the Global Historical Climatology Network (GHCN) database (Peterson and Vose 1997) and Climate Research Unit (CRU) database (Jones and Moberg 2003) indicate a warming temperature trend in the Arctic between 1900–2003 of 0.16°F (0.09°C) per decade (Symon et al. [eds.] 2005). In general, temperatures increased from 1900 to the mid-1940s, decreased until the mid-1960s, and then increased again up to the present time. Climate models project more warming in the Arctic compared to the rest of the world (Intergovernmental Panel on Climate Change [IPCC] 2007). At this time, there is no definitive evidence of an anthropogenic (human-induced) signal in the Arctic that may be a factor in causing this warming (Symon et al. [eds.] 2005). However, there is much debate over the potential contribution of human activities to climate change. The scarcity of data, as well as natural fluctuations in the Arctic, are more pronounced than in the rest of the world, making it challenging to determine causal factors of the observed recent temperature trend.

Other climate change trends observed in the Arctic include increasing precipitation, declining snow cover, melting glaciers, thawing permafrost, retreating summer sea ice, and rising sea level (Hassol 2004). Arctic precipitation has increased approximately 8 percent during the past century. Snow cover extent has declined about 10 percent, and permafrost has warmed by several tenths of a °C up to 2°C (3.6 °F) in the past 30 years. Most Arctic glaciers and ice caps have been in decline since the early 1960s, with the rate of change increasing in the 1990s. Arctic sea level has risen 10–20 centimeters in the past 100 years. Global average sea level rose almost 3 millimeters per year during the 1990s, an increase from about 2 millimeters per year in the preceding several decades. The annual average sea ice extent has decreased by about 8 percent and the summer sea ice extent has decreased by 15–20 percent during the past 30 years. Sea ice has also become thinner in recent decades, with arctic-wide average thickness reductions estimated at 10–15 percent. The reduction of sea ice and thawing of permafrost along the Arctic coast makes the shoreline more vulnerable to coastal erosion (Hassol 2004).

3.1.5.3 Effects on Arctic Natural Systems and Communities

Hassol (2004) determined climate change is evident in the Arctic and predicted observed trends are anticipated to continue. Continued climate change trends would affect the Arctic environment, including tundra and other vegetative communities, sea ice, sea level, and changes in the permafrost depth (Hassol 2004). Should observed trends in fact continue, the ACIA study predicts changes in Arctic natural systems. Vegetation patterns are expected to change, with forests replacing tundra, and tundra vegetation invading previously barren areas (Hassol 2004). A reduction in sea ice would affect marine mammals (particularly walruses, ice seals, and polar bears), fish, and birds, with related implications for Alaska Native subsistence harvests. Species ranges are predicted to move northward, and some Arctic species populations may move elsewhere or decline because of a loss of habitat, availability of food sources, or increased competition with other species. Migratory patterns could also change; for example, early thawing of rivers may impact caribou migrations to calving grounds (Hassol 2004).

Hassol (2004) also determined the current climate change trend would contribute to a rise in sea level, reduced ice cover, and increased storm activity and coastal erosion, thereby negatively affecting coastal communities. Potential sea level rise and thawing of the tundra could have negative effects on transportation, buildings, and infrastructure, including oil- and gas-related infrastructure. The current climate trend also has implications for oil and gas activities, notably shorter tundra travel and ice road seasons, and perhaps extended open water and barging opportunities. A reduction in Arctic sea ice, however, would likely enhance marine transportation and allow increased offshore energy development (Hassol 2004).

Many indigenous communities of the Arctic depend primarily on harvesting and using living resources from the land and the sea for subsistence, social identity, spiritual life, and cultural survival (Hassol 2004). The Arctic Indigenous Peoples perceive that the Arctic is becoming an environment at risk - with less stable sea ice, more unusual weather patterns, changes to vegetation cover, and subsistence use animals no longer being found in traditional hunting areas during subsistence hunting seasons (Hassol 2004).

3.1.5.4 Permafrost

Permafrost temperatures have increased throughout Alaska since the late 1970s (Lettenmaier et al. 2008). The University of Alaska Fairbanks has obtained permafrost temperature records along the International Geosphere-Biosphere Programme Alaskan Transect, which spans the entire continuous permafrost zone in the Alaska Arctic, since the early 1980s. Records from all locations (West Dock, Deadhorse, Franklin Bluffs, Galbraith Lake, and Happy Valley) along the transect showed warming during this period. The amount of warming varied at different locations, but was typically 0.9–3.6°F (0.5–2°C) at the 65.6 feet (20-meter) depth of zero seasonal temperature variations in permafrost. The temperature data also indicate that periods of relative cooling occurred in the mid-1980s, in the early 1990s, and again in the early 2000s. The warming was seasonal, primarily in winter, with shallower-than-normal winter snow cover with little changes seen during summer (Osterkamp 2003). More recent temperature measurements suggest the magnitude of warming was 5.4–7.2°F (3–4°C) for the ACP and 1.8–3.6°F (1–2°C) for the Brooks Range including its northern and southern foothills (Osterkamp 2007).

3.1.5.5 Coastal Erosion

The reduction of sea ice and thawing of permafrost along the Arctic coast makes the shoreline more vulnerable to coastal erosion (Hassol 2004). Sea ice retreat allows larger storm surges to develop in the increased open water areas, thereby increasing coastal erosion. Severe erosion has been observed on coastlines where permafrost has thawed (Weller 1998). Aerial photograph comparison has revealed total erosive losses up to 1,500 feet (600 meters) during the past few decades along some areas of the western Alaska coast (Weller and Anderson 1998). The mean annual rate of erosion along the Beaufort Sea has doubled during the past 50 years (Jones et al. 2009).

3.1.5.6 Sea Ice

The Arctic sea ice, including the Beaufort Sea sea ice, is undergoing rapid changes. Multiple investigators have reported changes in sea ice extent, thickness distribution, age, and melt duration (MMS 2008). The ACIA reported the annual average sea ice extent and the summer sea ice extent decreased 8 percent and 15–20 percent, respectively (Hassol 2004). Sea ice has also become thinner in recent decades with Arctic-wide average thickness reductions estimated at 10–15 percent (Hassol 2004). Investigators have found the distribution of ice is changing, its age is decreasing, and the melt duration is increasing. These factors lead to a decreasing perennial Arctic ice pack.

Investigators using climate models predict the Arctic will be ice-free during summer in the later part of the 21st Century (IPCC 2007). However, there is significant uncertainty in the summer sea ice estimates using the climate models. Some investigators predict 40–60 percent summer ice loss by the middle of the 21st Century (Holland 2006). Other investigators believe it may be sooner than what the models predict and possibly as soon as 2013 (Stroeve et al. 2008).

The cause(s) behind the reduction in summer sea ice extent are not fully identified. Evidence suggests the combination of oceanic and atmospheric conditions are contributing to sea ice loss. Incremental solar heating and ocean heat flux, longwave radiation fluxes, changes in surface circulation, and less multiyear ice may each account for sea ice loss (MMS 2008).

3.1.6 Noise

3.1.6.1 Introduction

This section describes the existing conditions related to noise in the Project area. It includes a description of the fundamentals of acoustics, identification of sensitive human receptors in the area, and a general description of the existing noise environment. Identification of and potential noise impacts on wildlife receptors will be addressed in the biological resources sections.

3.1.6.2 Noise Background

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear. Sound is generally characterized by several variables, including frequency and amplitude. Frequency describes the sound's pitch (tone) and is measured in cycles per second, or Hertz (Hz). Amplitude describes the sound's pressure (loudness). Because the range of sound pressures that occur in the environment is extremely large, it is convenient to express these pressures on a logarithmic scale that compresses the wide range of pressures into a more useful range of numbers. The standard unit of sound measurement is the decibel (dB).

The human ear is not equally sensitive at all frequencies: it is less sensitive at low frequencies and extremely high frequencies than at the mid-range frequencies. To obtain levels that are closer to the actual perception of loudness by the human ear, loudness judgements, frequency weighting is incorporated into sound level meters to alter the sensitivity. The A-weighted sound level (dBA) is the most widely used scale, as it simulates the hearing of humans. In this report, all sound levels related to effects of noise on humans are reported in dBA and sound levels related to wildlife (underwater or airborne) are not weighted.

There are many ways to rate sound for various time periods. An appropriate rating of ambient noise affecting humans accounts for the annoying effects of sound by penalizing noises that occur during quiet periods of time, such as late night/early morning, through a weighted averaging metric. Single-event or peak noises are measured by a simple peak noise measurement. The noise descriptors used in this report include day-night noise level (L_{dn}), equivalent level (L_{eq}), and maximum noise level (L_{max}). L_{dn} is a 24-hour average sound level with 10 dBA added to nighttime (10 p.m. to 7 a.m.) noise levels to account for increased sensitivity. L_{eq} is the total sound energy over a sample period, often expressed in one hour. L_{max} is the highest time-averaged sound level in a certain time period. Typical community noise levels are presented in Figure 3-13 and Table 3-21.

TABLE 3-21: SOUND LEVELS OF TYPICAL NOISE SOURCES (A-WEIGHTED SOUND LEVELS)

Noise Source (at Given Distance)	Scale of A-weighted Sound Level in Decibels
Civil Defense Siren (100 feet)	130
Commercial Jet Take-off (200 feet)	120
Pile Driver (50 feet)	110
Ambulance Siren (100 feet) Newspaper Press (5 feet) Power Lawn Mower (3 feet)	100
Propeller Plane Flyover (1,000 feet) Diesel Truck, 40 mph (50 feet) Motorcycle (25 feet)	90
Garbage Disposal (3 feet)	80
Passenger Car, 65 mph (25 feet) Living Room Stereo (15 feet) Vacuum Cleaner (3 feet)	70
Air Conditioning Unit (100 feet) Normal Conversation (5 feet)	60
Light Traffic (100 feet)	50
Bird Calls (distant)	40
Soft Whisper (5 feet)	30

Source: Compiled by URS Corporation from various published sources and widely-used references such as The Handbook of Acoustical Measurements and Noise Control, Third Edition, edited by C.M. Harris, 1991

3.1.6.3 Sensitive Land Uses in the Project Vicinity

Certain land uses are considered more sensitive to noise than others. Typical examples include residential areas, educational facilities, hospitals, childcare facilities, senior housing, and outdoor park and recreational areas. The nearest residential land uses are located 60 miles to the east in Kaktovik. The nearest developed areas located west of the Project site would be in Prudhoe Bay, approximately 60 miles away.

However, residents of Kaktovik occasionally visit the area to hunt caribou from the coast in the summer and pass through the area during the winter on snowmachines when traveling between communities. The summer period and associated hunting activities are the most sensitive time from this perspective.

The nearest outdoor recreational area is the Refuge coastal plain located a few miles southeast of the Project site. Recreation activities occur during the summer, and predominantly consist of nonmotorized floating down the Canning River for a wilderness experience. Access is provided by chartered single-engine aircraft. The level of recreation use is described in Section 3.3.6.

3.1.6.4 Existing Noise Environment

Ambient noise levels vary throughout the area of land to be used for Project construction and operation. Noise levels vary on the basis of population density, distance to nearby traffic corridors and other localized sources, aircraft flight patterns, nearby wildlife (e.g., chirping birds) and natural features (water), weather, and other various conditions. Because a majority of the area within and around the Project site is scarcely populated, low ambient noise levels can be expected. In an Environmental Impact Statement (EIS) prepared by the USDOI-BLM, for the Project "Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way," (ROW) it is stated that typical ambient noise levels in sparsely populated rural areas can range from 15–45 dBA L_{eq} (21–51 dBA L_{dn}). Noise levels in more populated areas will more than likely be higher and will vary by proximity to man-made noise sources.

Natural sources of existing noise include wind, water, ice movement, and wildlife. Anthropogenic noise sources include aircraft (fixed-wing and helicopters), current oil and gas operations (drilling, etc.), vessels, hunting, and recreational users.

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 Marine Benthos

Most of the nearshore seabed of the Alaska Beaufort Sea consists of a soft-bottom featureless plain composed of mud and silty sand (Barnes and Reimnitz 1974); hard substrates in the form of cobbles and boulders occur sporadically (MMS 1990a). Boulder/cobble substrate needed to support boulder patch communities characterized by rich, kelp-dominated flora and fauna has not been observed at the proposed dock area or elsewhere in Lion Bay.

Benthic communities constitute the living component of habitat. Benthic organisms function as prey, predators, and competitors, and can provide shelter on a substrate. Benthic invertebrates typically are classified as either epifauna (on or near surface of the substrate) or infauna (within the substrate). The benthic communities associated with soft-bottom benthic habitat include microalgae, bacteria, and an assemblage of polychaete worms, tiny mollusks, and benthic amphipods (MMS 1990a). The organisms comprising these groups, as well as the general patterns of their distribution and abundance, have been described in the Final EISs for OCS Lease Sales 97, 109, 124, and 144 (MMS 1987a, 1987b, 1990a, 1996, respectively); by Thorsteinson and Wilson (1983); the EIS for OCS Lease Sales 186, 195, and 202 (MMS 2003); the Environmental Assessment (EA) for OCS Lease Sale 202 (MMS 2006); and the Liberty EA (MMS 2007a).

On the basis of studies in similar Beaufort Sea habitats (Carey and Ruff 1977), the benthic community of the Lion Bay lagoon system is likely composed primarily of infaunal invertebrates (e.g., polychaetes, clams, and various crustaceans) and epifaunal invertebrates (e.g., amphipods, isopods, and mysids). The Beaufort Sea has fewer benthic species than other parts of the Arctic, because of the cold, unproductive arctic water masses and brackish conditions (Curtis 1975). Low numbers of benthic macrofauna species in the Arctic intertidal zone are usually attributed to ice scouring (Ellis 1955).

Epibenthos are 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 (attached to substrate) or sedentary (very-slow-moving) species also increases, as compared to the more motile and opportunistic species found closer to shore in shallower waters. Because depths within Lion Bay do not exceed 16–20 feet (5–6 meters), low benthos density and diversity is expected, as is characteristic within the nearshore zone of other areas along the Beaufort Sea coast. The nearshore zone extends from the shoreline to 6.6 feet (0–2 meters). The presence of the shore-fast ice in the nearshore zone prevents most species from over-wintering in this zone. Therefore, the nearshore benthic community is dominated by motile (fast-moving), opportunistic species that can re-colonize the area each year after the ice melts in the spring (Broad 1977; Broad et al. 1978; Feder et al. 1976; Grider et al. 1977, 1978; Chin et al. 1979a, 1979b). Distribution and abundance of most species is likely dependent on annual (or more frequent) colonization.

The diversity and biomass of infauna increase and species composition changes in the inshore environment where water depths range from 6.6–33 feet (2–10 meters). Biomass and diversity in the inshore zone generally increase with depth, except in the shear zone, where the moving pack ice shears against shore-fast ice and shore. Dominant motile invertebrates that live near the seafloor include amphipods, mysids, copepods, and other swimming crustaceans. These organisms are food for some fishes, birds, and marine mammals (Frost and Lowry 1981). Although shore-fast ice can occur in the shallower end of the inshore zone, this zone can support a greater diversity of benthic organisms and up to about 10 times the biomass of the nearshore zone.

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 of less than 6.6 feet (2 meters). 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 most substrates in the Beaufort Sea are silty sediments that are generally unsuitable for settlement and growth of large algae, hard substrates in the form of cobbles and boulders occur sporadically (MMS 1990a). Boulder/cobble substrate needed to support boulder patch communities has not been observed at the screeding or dredging areas, or elsewhere in Lion Bay. However two distinct areas with kelp habitat have been found seaward of the barrier islands (Figure 3-14).

Abundance and distribution data exist from the nearshore Arctic Coast, including Prudhoe Bay, from a NOAA Outer Continental Shelf Environmental Assessment Program (OCSEAP) study (Broad et al. 1978, 1979, 1981). Broad et al. used bottom grabs and trawls to collect infaunal and epifaunal organisms at three Prudhoe Bay sites. Mean biomass values at these sites were 4.93, 27.6, and 34.08 grams per square meter (g/m^2). Polychaete worms and small mollusks were the predominant infaunal organisms. Dominant epifaunal organisms included the isopod *Saduria entomon* and *S. sabini*, nemerteans, and benthic amphipods. Mollusks consisted of 75–80 percent of total biomass and polychaetes 10–15 percent. *Portlandica arctica* and *Macoma* spp. were the most abundant bivalves.

3.2.2 Vegetation and Wetlands

3.2.2.1 Soils

The Project is located on the ancient Canning River alluvial fan. The physical environment controls most plant establishment and growth. The soil in the Project area has been described as lowland loess, a soil formed primarily by wind-blown silt (Carter 1988). This type of soil favors the development of plant communities dependent on low acidity (i.e., high pH) and high mineral soils (Walker and Everett 1991). 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 because of the relatively low clay content of these alkaline tundra soils (Bilgin 1975; Walker and Everett 1991). At higher pH values (pH greater than 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; phosphorous 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; 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).

3.2.2.2 Geomorphology

Geomorphic processes, the interaction of geology and natural forces, 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. Within a few years following drainage, the wet basins are colonized by pioneer graminoid plant (grasses, sedges, and rushes) and moss species (Ovendon 1986). Wet basin floristic composition 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 1,500–2,500 years (Billings and Peterson 1980). Initial plant invaders and successional sequences vary within and between regions because of 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.

3.2.2.3 Vegetation and Wetlands

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 Hopson to the western edge of the Staines River, including Point Thomson and Flaxman Island (see Appendix A). The southern boundary generally extends approximately 1–2 miles (2–3 kilometers) inland, with exceptions including a corridor along the Staines River that extends approximately 7.5 miles (12 kilometers) inland, and Point Thomson where the boundary extends to the southwest up to 3 miles (5 kilometers). A total of 32,939 acres (13,330 hectares [ha]) was mapped. The final vegetation map for the Project (see Appendix A), which also includes the Badami Development area previously mapped (BP Exploration [Alaska] [BPXA] 1995), encompasses a total of 57,392 acres (23,225 ha).

A follow-up desktop vegetation analysis was conducted in 2009 (OASIS 2009) for the specific purpose of filling a small gap (an area of 1 square mile) in the initial 1998 analysis. The current East Pad Road alignment passed through this previously unmapped area. Following the vegetation scheme used in 1998, researchers evaluated high-resolution aerial photography to define the vegetation types within the unmapped area. This analysis resulted in an additional 640 acres (259 ha), which, when added to the 57,392 acres noted above, totals 58,032 acres (23,485 ha) of mapped area for the Project.

Water and wetlands are the predominant cover classes within the Project area: 33.3 percent of the project area is covered by water, including subtidal bays and inlets, rivers, streams, lakes and ponds; and 65.3 percent of the project area is covered by wetlands, including the PSS/EM wetlands Moist Sedge, Dwarf Shrub/Wet Sedge Tundra Complexes and Moist Sedge, Dwarf Shrub Tundra (see Appendix A).

Predominant vegetation types within the vegetation survey area are Moist Sedge, Dwarf Shrub/Wet Sedge Tundra Complexes (31.7 percent of mapped vegetation) and Moist Sedge, Dwarf Shrub Tundra (22.7 percent of mapped vegetation). 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) (Table 3-22). *Salix* spp., *Dryas integrifolia*, mesic *Carex* spp., and a number of forbs dominate the polygon rims or high centers.

Salt marsh vegetation covers 2.7 percent of the vegetation survey area. Other vegetation types within the vegetation survey area include Wet Sedge Tundra (2.7 percent) and Dry Dwarf Shrub Lichen Tundra, including crustose and fruticose lichens (2.7 percent), with the remaining vegetation types each accounting for less than 2 percent of the vegetation survey area (Table 3-22). Human disturbances (gravel roads and pads and associated washouts) cover 0.2 percent of the vegetation survey area and are confined to exploratory pads constructed in the Project area.

Most of the vegetation types in the vegetation survey area are wetland plant communities (Table 3-22). 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 because of their gravel substrate and infrequent inundation. Tundra disturbed by gravel fill also may be converted to upland, depending on the thickness of the fill; placing a sufficient thickness of gravel may cause an area to lose hydric soil, hydrophytic vegetation, and/or wetland hydrology, all of which are required for an area to be a wetland.

Wetland types present in the vegetation survey area (represented by the applicable National Wetland Inventory [NWI] codes based on plant and surface water hydrology descriptions from the vegetation mapping) are detailed in Table 3-22 (Cowardin et al. 1979; Walker 1983; Noel and Funk 1999). The three most abundant vegetation types present in the vegetation survey area are further discussed below with their applicable NWI codes are:

- Water;
- Moist sedge, dwarf shrub, tundra/wet sedge tundra complex; and
- Moist sedge, dwarf shrub tundra.

Water comprises 33.3 percent of the vegetation survey area. NWI codes associated with mapped waterbodies in the vegetation survey area include estuarine subtidal (E1UBL); tidally influenced, upper perennial, and lower perennial riverine unconsolidated bottom waters (R1UBV, R2UBH, R3UBH); limnetic lacustrine unconsolidated bottom waters (L1UBH, L2UBH); and palustrine unconsolidated bottom waters (PUBH).

Moist sedge, dwarf shrub, tundra/wet sedge tundra complex constitutes 30.3 percent of the vegetation survey area and is characterized by 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). Moist sedge, dwarf shrub tundra comprises 21.9 percent of the Project area and is characterized by palustrine scrub shrub emergent wetlands (PSS/EM1B). Typically high-center polygons comprising *Salix pulchra*, *S. arctica*, *S. reticulata*, *Dryas integrifolia*, *Carex misandra*, *C. bigelowii*, and *C. atrofuscaa* are associated with this wetland type. Frost-scarred barren areas are also associated with this type.

3.2.2.4 Wetland Functions

Wetland functions are defined as a process or series of processes that take place within a wetland. Wetlands vary in effectiveness in performing functions and the inherent value of a wetland is dependent on both effectiveness of performing a function and the opportunity a wetland has to perform that function.

Hydrologic functions are those related to the quantity of water that enters, is stored in, or leaves a wetland. These functions include such factors as the reduction of flow velocity (flood control), the role of wetlands as groundwater recharge or discharge areas, and the influence of wetlands on atmospheric processes (Novitzki et al. 1997). Although hydrology is the most important factor explaining the development and maintenance of a wetland, other factors influence wetland functions, such as the position of the wetland in the landscape, the land use around the wetland, the density of vegetation in the wetland, the soils and geologic features, the source of water, and the size of a wetland.

There are three important factors influencing Alaska wetland hydrology (Ford and Bedford 1987):

- Measured annual precipitation exceeds calculated annual evapotranspiration, creating conditions suitable for the development of ombrotrophic wetlands (those fed by only precipitation);
- During snowmelt, which is the principal event in the annual hydrologic cycle, wetland soils typically have high ice contents, and thus probably do not contribute significantly to either flood storage or groundwater recharge; and
- The existence of permafrost is critical to the existence and functioning of much of the areal extent of wetlands in the state. Permafrost has low permeability and infiltration rates. As a result, recharge through permafrost is extremely slow (Ford and Bedford 1987). In areas where permafrost is continuous, there is virtually no hydraulic connection between groundwater in the surface layer and groundwater below the permafrost zone.

General wetland water-quality functions include the trapping of sediment, pollution control, and the biochemical processes that take place as water enters, is stored in, or leaves a wetland. Wetlands improve quality of surface water by reducing nitrogen, biological oxygen demand, suspended solids, pollutants, metal, and pathogens. The biogeochemistry of arctic wetlands is generally distinct from other arctic fresh water systems, with lower DO concentrations in Arctic wetlands, more extreme reducing conditions in sediments, and more favorable conditions for biodegradation (Wetzel 2001).

Habitat is defined as the part of the physical environment in which plants and animals live (Lapedes 1976), and wetlands are among the most productive habitats in the world (Tiner 1989). They provide food, water, and shelter for fish, shellfish, birds, and mammals, and they serve as a breeding ground and nursery for numerous species. Wetlands provide important spawning habitat for marine fish and invertebrates. Fish and invertebrates in turn provide waterfowl and marine birds with a plentiful source of food (DGC 1985). All rivers flowing into the Beaufort Sea, and the inland extent of anadromous fish populations, support species that are indirectly influenced by wetlands (DGC 1985).

3.2.2.5 Threatened and Endangered Species

Seventy-seven species of vascular plants and 17 nonvascular plants were identified during collection of ground reference data for the Project vegetation map. No threatened or endangered plant species are known to occur in the Project area. Several species of rare vascular plants occur on the North Slope and may be found within or near the Project area (Murray and Lipkin 1987, 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 (Murray and Lipkin 1997; FR 1994). This small (4.7–6.3 inches) (12–16 centimeters 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 1997). Other plants with global and state rarity rankings that occur on the North Slope include *Potentilla stipularis*, *Pleuropogon sabinei*, *Draba pauciflora* (syn. *Draba adamsii*), *Poa hartzii* ssp. *alaskana*, *Erigeron muirii*, and *Symphotrichum pygmaeum* (syn. *Aster pygmaeus*) (Alaska Natural Heritage Program [AKNHP] 2008). *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 turf polygons near the ocean or streams. *Poa hartzii* is a grass known from sites on the Meade River and within the Refuge 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 (NPR-A) 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.

TABLE 3-22: VEGETATION AND WETLAND TYPES THAT OCCUR IN THE POINT THOMSON AREA

Vegetation Type	Level C Types	Wetland Type[1]	Description/Dominant Plant Species	Total Area	
				Acres	Percent
Water	Bays, lagoons, inlets, subtidal rivers (Ia)	Estuarine subtidal (E1UBL).	Low-energy brackish water.	19,363.0	33.3
	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.	558.4	1.0
	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,* and *Cochlearia officinalis*.	289.6	0.5
	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*.	697.2	1.2
			Salt Marsh Total	1,545.2	2.7
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.	296.2	0.5
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).	206.7	0.4

Vegetation Type	Level C Types	Wetland Type[1]	Description/Dominant Plant Species	Total Area	
				Acres	Percent
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.	1,557.0	2.7
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).	608.3	1.0
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.	8,184.8	14.1
	Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (IIIe)	see above	see above	352.0	0.6
	Moist Sedge, Dwarf Shrub/Wet Graminoid Tundra Complex (IVa)	see above	see above	9,866.6	17.0
	Moist Sedge, Dwarf Shrub Tundra/Wet Sedge Tundra Complex Total			18,403.4	31.7
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.	9,809.5	16.9
	Moist Graminoid, Dwarf Shrub Tundra/Barren Complex (Ve)	see above	see above	2,921.0	5.0
	Moist Sedge, Dwarf Shrub Tundra Total			12,730.5	22.7

Vegetation Type	Level C Types	Wetland Type[1]	Description/Dominant Plant Species	Total Area	
				Acres	Percent
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.	2.3	<0.1
Dry Dwarf Shrub, Crustose Lichens	Dry Dwarf Shrub, Crustose Lichens (Vc)	Upland	Well-drained sites (commonly pingos) comprising *Dryas integrifolia*, *Salix rotundifolia*, *S. phlebophylla*, *Carex rupestris*, and a diversity of legumes and forbs. Exposed mineral soil covered with crustose lichens.	701.1	1.2
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, Vaccinium vitis-idaea* and mesic forbs (e.g. *Saxifraga punctata* and *Pyrola grandiflora*). Exposed peaty soil covered with fruticose lichens.	885.8	1.5
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.	369.6	0.6
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*.	56.1	<0.1
Dry Barren/Grass Complex	Dry Barren/Grass Complex (IXe)	Upland	Coastal sand dunes partially vegetated with *Elymus arenarius*.	6.7	<0.1

Vegetation Type	Level C Types	Wetland Type[1]	Description/Dominant Plant Species	Total Area	
				Acres	Percent
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, and Trisetum spicatum.	4.7	<0.1
River Gravels	River Gravels (Xa)	Riverine, seasonally flooded areas (R2USC, R3USC).		439.8	0.8
Bare Peat, Wet Mud	Wet Mud (XIa)	Exposed Lacustrine (L2USD) and Palustrine (PUSD) peat and sediments.	Drained lake basins.	661.6	1.0
	Bare Peat (XIc)	see above	see above	32.2	0.1
	Bare Peat, Wet Mud Total			693.8	1.1
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.	4.8	<0.1
	Gravel Roads and Pads (Xe)	see above	see above	94.6	0.2
	Gravel Roads and Pads (and washouts) (Xe, Xc) Total			99.4	0.2

Notes:
Source: Shapefiles by Noel and Funk 1999
[1] Study area was not specifically classified and mapped into wetland types, but rather vegetation types (Walker 1983) were reclassified into wetland types, based on U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) nomenclature (Cowardin et al. 1979).
< = less than

3.2.3 Fish

3.2.3.1 Fish of the Beaufort Sea

Forty-five species of fish are reported to live in the Alaska Beaufort Sea (Table 3-23). These fish can be classified in terms of three principal life histories: freshwater, diadromous, or marine, although with warmer trends in climate change and increases in the northern range of species, some diadromous fish such as Pacific salmon have been seen in the western Beaufort Sea (Craig and Haldorson 1986; Moulton 2001). The term diadromous is used to describe fish species that migrate between freshwater and estuarine or marine habitats on an annual basis (Gallaway and Fechhelm 2000). This includes anadromous fish such as salmon that leave marine waters to return to the freshwater habitats to spawn where they were born. By definition, freshwater species would spend their entire lives in rivers and lakes of the North Slope and generally avoid saline waters. In practice, however, most freshwater species on the North Slope, such as Arctic grayling and round whitefish, can show annual movements downriver to low-salinity estuarine and nearshore waters, particularly during early summer when freshwater runoff to coastal habitats is at a peak (Moulton and Fawcett 1984; Hemming 1993). Diadromous species, such as Dolly Varden, Arctic cisco, broad whitefish, and least cisco migrate back and forth each summer between upriver over-wintering areas and feeding grounds in Beaufort Sea coastal waters. This life strategy takes advantage of prey abundance in the nearshore zone that can be nine-fold or more higher than in freshwater habitats (Craig 1989b). Most marine species inhabit deeper offshore waters and are either rarely reported in the North Slope coastal zone, or move inshore following break-up of shorefast ice. Arctic cod, fourhorn sculpin, and Arctic flounder, for example, specifically migrate into shallow, low-salinity coastal waters and estuaries during summer (Bureau of Land Management [BLM] 2008).

3.2.3.2 Diadromous and Freshwater Fish

The distribution and abundance of diadromous fish in the Beaufort Sea is strongly influenced by reproduction and seasonal migration 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-mile (600-kilometer) 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 1989a) or rehabilitated mine sites. Dolly Varden and Arctic grayling are the two principal species that inhabit these mountain streams, although lakes associated with these drainages may contain lake trout. Ninespine stickleback are also widely distributed in ponds and streams within the western portion of the “mountain stream” range (Winters and Morris 2004). Pacific salmon species are rare in the Project area, although there is some evidence that the occurrence of salmon has been increasing over the past 20 years, perhaps as a consequence of warmer climatic conditions (BLM 2008). At present, small runs of pink salmon occur in the Sagavanirktok and Colville rivers, and spawning populations of chum salmon 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 are an abundant and important diadromous fish in the Project area (Fechhelm et al. 2009). Arctic cisco in the Alaska Beaufort Sea originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al. 1983, 1989). They arrive in the Prudhoe Bay area from mid-August through mid-September and in the Point Thomson area somewhat earlier (Fechhelm et al. 2009). Arctic cisco constitute one of the most abundant diadromous species found in the Alaska Beaufort Sea (Fechhelm et al. 2004, 2005, 2009), 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, 1993; Moulton and Field 1988, 1991, 1994; Moulton and Seavey 2004; Moulton 1994, 1995, 1996, 1997; BLM 2008).

TABLE 3-23: FISH SPECIES TAKEN IN NEARSHORE AND OFFSHORE WATERS OF THE WESTERN AND CENTRAL BEAUFORT SEA

Clupeidae
- Pacific herring (*Clupea pallasii*)

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

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

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

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

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

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

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

Agonidae
- Arctic alligatorfish (Ulcina olrikii)

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

Pholidae
- Rock gunnel (*Pholis gunnellus*)

Anarhichadidae
- Wolf-eel (*Anarrhichthys ocellatus*)

Ammodytidae
- Pacific sand lance (*Ammodytes hexapterus*)

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

Hexagrammidae
- Kelp greenling (*Hexagrammos decagrammus*)

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

3.2.3.3 Freshwater Habitat

The Project is located in the mountain stream zone of the North Slope. A majority of the freshwater habitat in the Point Thomson area is composed of seasonally flooded wetlands and ponds less than 4 feet deep. These ponded habitats originate from a complex freeze/thaw cycle on the ACP and, once formed, can persist for long periods before eventually filling in or being drained by surface streams (BPXA 1995; Degler undated). Wetlands and ponds generally freeze solid in the winter, and so provide only summer habitat for fish and invertebrates (BLM 2008); however, they can provide important feeding for fish if access is available, and rearing habitat for numerous bird species.

Streams in the Project area are mostly small and low-gradient. Flows can be dramatic during snowmelt, but then quickly recede to minimal levels (Winters and Morris 2004). As with area wetlands and ponds, these streams generally freeze solid in the winter and so likely provide only seasonal habitat for fish and invertebrates, although the ubiquitous presence of ninespine stickleback in these streams suggests some potential for overwintering by this species (WCC and ABR 1983; Winters and Morris 2004).

The Staines and Canning rivers immediately to the east and the Shaviovik and Kavik rivers situated about 31 miles (50 kilometers) to the west of Point Thomson offer large river habitats for fish and invertebrates, including some overwintering habitat. Both systems support populations of Dolly Varden, Arctic grayling, and ninespine stickleback. The Canning River also contains round whitefish, burbot, and slimy sculpin. The Staines and Canning river system is considered important summer feeding habitat for Dolly Varden. More generally, these rivers likely serve as important sources for a variety of fish found in marine and freshwater habitats in the Project area, though formal studies of dispersal from these systems are limited.

Freshwater over-wintering habitat is limited in North Slope rivers, particularly for Dolly Varden, which require higher DO levels than Arctic grayling and ninespine stickleback. Dolly Varden require areas with water depths greater than 7 feet or that have perennial warm-water springs for successful wintering and reproduction. Such deep-water habitats and springs provide fish with open water habitat throughout the winter and prevent eggs from freezing (Craig 1984; DFO Science 2002). 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 state their report only concerns those areas known to be important for fish and additional spawning and over-wintering sites will undoubtedly be located in the future (Craig and McCart 1974).

Despite this, Craig (1989a) 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. Since this study was published, additional areas of overwintering habitat have been identified, and gravel extraction activities have also created new habitat, so the extent to which winter habitats limit diadromous fish is not clear.

A number of studies have documented that both freshwater and diadromous fish species occur in many if not most pond and stream habitats in the Point Thomson area.

Hemming (1996) sampled two streams (No Name River, East Badami Creek) that enter Mikkelsen Bay east of the Project area. Fyke net surveys found high numbers of ninespine stickleback in both East Badami Creek and No Name River, with catch rates ranging from 243–1,525 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. These results were interpreted as evidence that juvenile Dolly Varden, and possibly other diadromous species, may enter these streams to feed during early summer when stream flow is high (Hemming 1996).

Visual surveys of six additional streams between East Badami Creek and the Staines River, ranging in length between 9 and 20 miles (15 and 32 kilometers), documented ninespine stickleback in all streams and fourhorn sculpin in the estuarine portion of one stream (WCC and ABR 1983).

The ADNR conducted stream surveys on 17 streams in the Project area to document species presence. All streams surveyed contained either ninespine stickleback, anadromous Dolly Varden or a combination of both species (ADNR 2002).

The Alaska Department of Fish and Game (ADF&G) Anadromous Waters Catalog (AWC) contains six streams between the Project area and the Badami Unit that have been identified as Dolly Varden rearing habitat.

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 miles (40 kilometers) of the coast. They reported finding fish in a number of these water bodies.

Winters and Morris (2004) conducted stream surveys with fyke nets for fish in August 2002 and July 2003 on the “mountain streams” that will be crossed by the Project. All of the 15 stream systems sampled in 2002 contained fish, and all but two of the 17 sampled in 2003 contained fish.

The Winters and Morris (2004) study is particularly informative because their sampled streams can be cross-referenced to specific proposed road-related stream crossings of the Project. Their sampled locations include Stream 18a (culvert), Stream 18b (50-foot bridge), Stream 22b (40-foot bridge), and Stream 22a (65-foot bridge). Of those listed, Stream 22b and Stream 22a were found to be fish-bearing streams with Dolly Varden in the lower sections. There were seven Dolly Varden collected in Stream 22b in 2002 and one in Stream 22a in 2002. Ninespine stickleback were found in all but one of these proposed stream crossings in both years.

The proposed Central Pad Road, which would run south from the coast and then east to the East Pad, will also cross several fish-bearing streams. Stream 24b (40-foot bridge) was found by Winters and Morris (2004) to contain ninespine stickleback at all sample locations (2002 and 2003), with Dolly Varden (2002) in the two lowest locations and fourhorn sculpin (2002) in the location closest to the coast. Stream 26 (culvert) was sampled almost a mile north of the proposed Central Pad Road and contained ninespine stickleback. The last crossing is over Stream 27 (culvert), which had ninespine stickleback and Dolly Varden in both 2002 and 2003.

The mountain streams, wetlands, and ponds within the Project area have the potential to provide excellent habitat for the production of macroinvertebrates, which can be an important food source for fish (MJM 2007) and waterfowl (Kertell 1993). Studies of the Prudhoe Bay oil field in the 1991 and 1992 summer seasons found abundant populations of invertebrates in both open water and areas with emergent vegetation (Kertell 1993). The types of macroinvertebrates were found to be related to the presence or absence of emergent vegetation, and within emergent vegetation on whether sedge or grass species dominated. Chironomids (midges) and oligochaetes (worms) dominated open water habitats, whereas Plecoptera (stoneflies), Trichoptera (caddisflies), and Gastropods (aquatic snails) were predominant in emergent vegetation (Kertell 1993). Within habitats containing emergent vegetation, pendant grass (*Arctophila fulva*) contained larger numbers of invertebrates than areas dominated by water sedge (*Carex aquatilis*) (Kertell 1983). Similarly, a study conducted in the Teshekpuk Lake region, west of the Project area, found midge larvae were the dominant invertebrate in the majority of sampling locations (MJM 2007). The authors also found large numbers of aquatic snails and caddisflies in several sample locations.

Roads associated with petroleum production facilities can result in areas of impounded water. Chironomids are often the first colonizers in impoundments (Rosenberg et al. 1986), and these habitats in the Prudhoe Bay area were found to have 2–10 times more chironomids and oligochaetes than natural ponds and lakes (Kertell 1993). Sampling of emergent vegetation found that there were greater numbers of caddisflies, stoneflies, and aquatic snails in impoundments than in similarly sized natural ponds (Kertell 1993). Temperate impoundments tend to peak in invertebrate production approximately three to four years after the initial flooding, and the decreases observed in the following years have been attributed to a decline in chironomids (Danell and Sjoberg 1982). This same progression may also be true for arctic systems, but the timeline is likely to be prolonged (10–20 years instead of three to four) because of colder soil temperatures (Johnson 1987).

Based on studies of other, nearby drainages (LGL 2000b; BLM 2008), the streams within the Project area are expected to have high water quality, especially early in the season with the influx of freshwater from the spring snowmelt. Generally these streams are soft, dilute calcium-bicarbonate waters with slightly alkaline pHs and limited buffering capability (Winters and Morris 2004; BLM 2008). An exception to this characterization can occur during the winter, when ice formation forces a variety of dissolved ions into the remaining free water fraction. During such times, the total dissolved solids and alkalinity can increase markedly, with a resulting increase in “off flavors” and saline taste (BLM 2008). In addition, the limited monitoring of fecal coliform bacteria has revealed high levels during the summer ice-free zone, likely due primarily to fecal material from lemmings and birds (BLM 2008).

Winters and Morris (2004) evaluated water quality in the summers of 2002 and 2003 on a number of streams and ponds within or just west of the Project area. The streams averaged 2 feet deep and approximately 28 feet long. There was little to no flow in most locations, but those with measurable flow were all less than 2 cfs. There was a relatively high average DO content of 10.14 mg/L with the lowest measurement of 8.23 mg/L, and pH values of 7.4–8.3, well within the acceptable range documented for juvenile salmonids (Carter 2005). Refer to Section 3.1.3 for more detailed information about water quality in the Project area.

3.2.3.4 Coastal Habitat

The prominent coastal feature in the Project area is Lion Bay (Figure 3-12). It is a barrier island lagoon system located approximately 51 miles east of Prudhoe Bay and is approximately 2.4–3 miles wide and averages 9–12 feet in depth. It is connected to the Beaufort Sea via Mary Sachs Entrance. The eastern end of Lions Bay is formed by the convergence of Flaxman Island and the mainland near Brownlow Point. It represents a local foraging area for several marine species, including several diadromous fish species (LGL 2000b). As in previous nearshore studies conducted in nearshore areas located to the west (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths 1983; WCC 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al. 1995a, 1996, 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 ppt in the study region (LGL 2000b). Salinity remained low at stations east of the Project site, gradually increasing to near 20 ppt by early August and 30 ppt by mid-August. In contrast, stations at or west of the Project site 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 inverse trend, with the eastern stations tending to be warmer than the western stations, probably because of higher inputs of relatively warm freshwater, and with temperatures decreasing during summer as these inputs decreased. In early to mid-July, water temperatures ranged to 45–46°F (7–8°C), decreasing to 37–39°F (3–4°C) by mid-August (LGL 2000b).

Productivity of the coastal marine habitat is driven by two different primary producers, epontic (ice) algae and phytoplankton. Each of these has a seasonal importance and role as a primary food source for nearshore coastal habitat such as Lion Bay. Epontic algae are important to nearshore habitats in late spring and early summer as sunlight becomes more abundant and temperatures begin to rise. Ice algae blooms occur in the spring because of increasing periods of daylight and nearshore waters that are rich in nutrients (Campbell 1981). Horner and Schrader (1981) reported that epontic algae were responsible for nearly all of the primary production in Stefansson Sound off Prudhoe Bay in winter and spring. By some estimates, epontic algae contribute 5 percent of the annual total primary production in nearshore Beaufort Sea coastal waters (Schell and Horner 1981). Under clear ice conditions, Dunton (1984) found that ice algae contributed about 25 percent of the carbon produced in the Stefansson Sound Boulder Patch.

As the ice begins to break up and coastal circulation is restored, phytoplankton begin to take over as the dominant primary producer. Phytoplankton abundance is generally highest in nearshore waters (Schell et al. 1982a, 1982b; Horner 1984), and there is a general trend of decreasing productivity with increasing distance from shore (Campbell 1981). Production also appears to be higher in the Canadian Beaufort Sea than in the Alaska Beaufort Sea because of the contribution of nutrient-rich discharge waters from the Mackenzie River (Hsiao 1976). Pockets of higher primary production also occur at Barrow in conjunction with an annual influx of plankton-rich waters from the Bering Sea, and at Barter Island because of localized upwelling events that increase nutrient levels (Schell 1988). The total productivity of summer phytoplankton per unit area (e.g., square foot) is from 2.5 to more than 40 times the productivity of ice algae (Schell et al. 1982a, 1982b).

In the case of Lion Bay, where water tends to be warmer and more nutrient-rich than in other parts of the Beaufort Sea because of inputs from the Staines and Mackenzie rivers, there is potential for the nearshore habitat associated with the Project to sustain higher primary productivity than in many other nearshore areas. This production sustains, either directly or indirectly, several primary consumer groups, including marine zooplankton such as copepods, mysids, and euphausiids, and free-living epibenthic organisms such as benthic copepods, amphipods, and isopods (Griffiths et al. 2002). This represents a significant resource for many organisms, including transient populations of fish (marine and diadromous) and marine mammals.

The Lion Bay barrier-island lagoon system is a major migratory pathway for diadromous species, including Dolly Varden 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). The productivity and prey availability in nearshore coastal waters can be nine times, or more, greater than adjacent freshwater habitats (Craig 1989b). Many of these fish therefore rely heavily on this coastal habitat during summer months for food. Epibenthic and planktonic crustaceans such as amphipods, mysids, isopods, and copepods are especially important as prey species (BLM 2008).

A synopsis of the life histories of the major fish species found in Lion Bay, as well as species of interest, is provided below.

Arctic Cisco

Arctic cisco are an abundant and important diadromous fish in the project area (Fechhelm et al. 2009). Most Beaufort Sea Arctic cisco (Iñupiaq name = Qaataq) are believed to originate from spawning grounds in the Mackenzie River system of Canada (Gallaway et al. 1983, 1989; Bickham et al. 1989; Morales et al. 1993). In spring, newly hatched fish are flushed downriver to ice-free coastal waters, where large numbers are transported westward 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; Colonell and Gallaway 1997). Once in Alaska, fish take up overwintering residence in some of the larger North Slope drainages, such as the Colville and Sagavanirktok rivers (Griffiths and Gallaway 1982; Critchlow 1983; Woodward-Clyde Consultants [WCC] 1983; Moulton et al. 1986; Glass et al. 1990; Griffiths et al. 1983, 1995b, 1996, 1997; Fechhelm et al. 2004; Fechhelm and Griffiths 2001). Although the Sagavanirktok River may provide overwintering habitat for juvenile fish, the Colville River appears to be the only Alaska drainage large enough to support substantial populations of sub-adult and adult Arctic cisco throughout the winter (Schmidt et al. 1989; Adams and Cannon 1987).

Despite the inability of the mountain streams between the Colville and Mackenzie rivers to support spawning populations of adult Arctic cisco, 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, 1977; West and Wiswar 1985; Wiswar and West 1987; Griffiths 1983; Fruge et al. 1989; Underwood et al. 1995). Lion Bay is no exception, although the abundance of adult Arctic cisco tends to fluctuate throughout the summer as schools of fish pulse through the area, often in response to strong wind events. During 1999, Arctic cisco were the most abundant fish caught by fyke nets in the lagoon (LGL 2000b). Another review of data from the Prudhoe Bay region found they were the most abundant species over the past 26 years (Fechhelm et al. 2009).

Data collected from the Prudhoe Bay region also 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 1983; WCC 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al. 1995b, 1996, 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; Fechhelm et al. 2009). These year-class gaps eventually manifest themselves in the commercial and Alaska Native subsistence fisheries of the Colville River (Moulton et al. 1990, 1992, 1993; Moulton and Field 1988, 1991, 1994; Moulton 1994, 1995).

Although smaller drainages east of the Sagavanirktok River appear to be unimportant for overwintering of Arctic cisco, there is more uncertainty about the importance of the Canning River. It is the third largest drainage on the Alaska 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 (4–5 inches [100–120 millimeters] in length; approximate size for one-year-old fish) at Simpson Cove, located 19 miles (30 kilometers) east of the Canning River, in July of 1988 and 1990. Whether these young fish came from the Sagavanirktok River (81 miles [130 kilometers] west), the Mackenzie River (223.7 miles [360 kilometers] east), or possibly the nearby Canning River, is unknown. Results from sampling in 1999 suggested that overwintering capacity in the Point Thomson and Canning River areas is very limited (LGL 2000b). Few age one and age two 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 Project region, the early season catches should have been much higher.

Dolly Varden

Although the coastal mountain streams between the Colville River in Alaska and the Mackenzie River in Canada provide rearing habitat for diadromous Dolly Varden (Iñupiaq name = Iqalukpik) populations, it does not appear that there is sufficient free-water habitat for Dolly Varden to overwinter in them. The potential source populations for these spawners therefore appear to be the Canning/Staines and Shaviovik rivers (Winters and Morris 2004).

Typically, juvenile Dolly Varden remain in their natal streams for two to three years after hatching before migrating to coastal waters (Craig 1977a, 1977b, 1989a; LGL 2000b). After two to three years in freshwater, they will begin to migrate along the coast during the summer and return to freshwater streams, although not necessarily their natal stream, with open water habitat to overwinter (Craig 1984). Sexual maturity is usually reached at seven to nine years, at which point they return to their natal stream to spawn. An alternate life history strategy for some salmonid males is precocious maturation, where the males do not migrate to saline water, but rather mature at a younger age and smaller size in freshwater (Craig 1977a, 1977b; DFO Science 2002). These precocious males will then mate with diadromous females by "sneaking" into redds while the female is spawning with another diadromous male (DFO Science 2002). Fish age two and younger and nondiadromous males therefore reside and feed in riverine environments throughout the summer.

During the summer months, diadromous Dolly Varden undergo extensive migrations along the coast and may even feed among ice floes offshore later in the summer (LGL 2000b). A study conducted in the Point Thomson nearshore region found Dolly Varden were the second most abundant diadromous fish caught in Lion Bay, and the third most abundant species overall (LGL 2000b). These findings indicate Lion Bay may provide important marine foraging grounds for local populations, most likely the Canning/Staines River spawning populations (LGL 2000b). During migrations along the coast, juvenile Dolly Varden also use small streams within the Project area to feed. Winters and Morris (2004) observed high inter-annual variation in catch rates of these juveniles; a total of 42 Dolly Varden were caught in August 2002, compared with only four in July 2003. This variation in catch may be attributed to the later sample dates in 2002, which could have allowed more time for juveniles to migrate from the source population river systems.

Least Cisco

Least cisco (Iñupiaq name = Iqalusaaq) exhibit two different life-history strategies. Some are diadromous, whereas others are strictly freshwater forms (McPhail and Lindsey 1970; Scott and Crossman 1973). Diadromous least cisco in the Beaufort Sea are associated with two main population centers. Alaska populations occur in "tundra" rivers that lie west of, and include the Colville River, while Canadian populations are associated with the Mackenzie River watershed (Craig and McCart 1975; Craig 1984, 1989b). There are no known spawning populations associated with the Sagavanirktok River or with the "mountain streams" that lie along the 373 miles (600 kilometers) of coastline between the Mackenzie and Colville rivers (Craig 1984). Because of proximity to the two least cisco population centers, it is assumed that most adult and therefore any juvenile least cisco found in coastal waters of the Prudhoe Bay area are from Colville River stocks.

Adult least cisco regularly reach the Sagavanirktok Delta during summer (Griffiths and Gallaway 1982; Critchlow 1983; Griffiths 1983; WCC 1983; Moulton et al. 1986; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al.

1995b, 1996, 1997). They have also been reported to be extremely abundant in Mikkelsen Bay, 93 miles (150 kilometers) east of the Colville River and 25 miles (40 kilometers) west of Lion Bay (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 Lion Bay. The vast majority of these least cisco were in excess of 10 inches (250 millimeters), which indicates that 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. Because least cisco caught in Prudhoe Bay are considered to originate exclusively from the Colville River (Fechhelm et al. 2009), the capture of these tagged fish is additional evidence that least cisco found in the Project area are also likely to be from the Colville River.

Juvenile least cisco are not expected in the Lion Bay area. Juveniles (less than 7 inches [180 millimeters]) from the Colville River travel to the marine nearshore before dispersing as far east as the eastern end of Simpson Lagoon, approximately 50 miles (80 kilometers) west of the Project Area. Dispersal this far east does not occur every year (Fechhelm et al. 1994). It is doubtful that the dispersal range of these small fish would extend another 56–62 miles (90–100 kilometers) eastward to Lion Bay. 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 Lion Bay in 1999 (LGL 2000b).

Least cisco is one of the most abundant species found in Beaufort Sea coastal waters during summer (Griffiths and Gallaway 1982; Griffiths et al. 1983; Fawcett et al. 1986; Moulton et al. 1986; Cannon et al. 1987; Fruge et al. 1989; Glass et al. 1990; Underwood et al. 1995; Griffiths et al. 1995, 1996, 1997; Fechhelm et al. 2004, 2005). They are also one of the principal species targeted in the fall Colville River subsistence fishery (Pedersen and Shishido 1988; Moulton 1994, 1995, 2001, 2003; Moulton and Field 1988, 1991, 1994; Moulton and Seavey 2004, 2005).

Broad Whitefish

There are two main population centers of broad whitefish (Iñupiaq name = Aanaaqliq) in the Alaska/Canadian Beaufort Sea. Alaska populations are typically associated with “tundra” rivers that lie west of and including the Sagavanirktok River, while Canadian populations are associated with the Mackenzie River (Craig and McCart 1975; Craig 1984, 1989b). There are no known spawning populations of broad whitefish in the “mountain streams” along the 310 miles (500 kilometers) of coastline between the Sagavanirktok River and the Canadian border. Juvenile broad whitefish appear to be intolerant of high salinities and typically remain in close proximity to their natal river deltas (Fechhelm et al. 1992).

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 two 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; WCC 1983; Moulton et al. 1986; Moulton and Fawcett 1984; Cannon et al. 1987; Glass et al. 1990; LGL 1990, 1991, 1992, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al. 1983, 1995, 1996, 1997). Few young fish were found in Mikkelsen Bay in 1995 (Fechhelm et al. 1996) or in Lion Bay in 1999 (LGL 2000b). In 2000, only three broad whitefish of the 491 caught were less than approximately 11 inches (280 millimeters).

Older broad whitefish (age three 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 Lion Bay in 1999. Broad whitefish caught in Lion Bay were primarily between 11–19 inches (280–480 millimeters) in length. Fish of this size are consistent with broad whitefish ranging from ages 4–15 from the Saganvanirktok River (LGL 2000b). Broad whitefish catches reported for the eastern Alaska Beaufort Sea have been very small or zero (Griffiths 1983; West and Wiswar 1985; Wiswar and West 1987; Fruge et al. 1989; Underwood et al. 1995).

The broad whitefish is the principal species targeted in the summer subsistence fishery in the Colville River (Moulton et al. 1986; Nelson et al. 1987).

Humpback Whitefish

Humpback whitefish (Iñupiaq name = Qaalriq) have a segmented distribution in the river systems of the Beaufort Sea. Eastern populations are associated with the Mackenzie River and several smaller rivers of the western Canadian Arctic (Craig 1984). Western populations are found in the Colville River, Alaska, and numerous rivers further to the west (Alt and Kogl 1973; Kogl and Schell 1974; Bendock 1979). There are no known populations inhabiting the rivers between the Colville River and the U.S.-Canadian border (Craig 1984). Humpback whitefish neither spawn nor overwinter in the Sagavanirktok River drainage (Fechhelm 1999). Like broad whitefish, humpback whitefish are intolerant of high salinity conditions and remain in brackish nearshore waters and river deltas throughout the summer (Fechhelm 1999).

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; WCC 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, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al. 1995, 1996, 1997), although they had been relatively abundant in limited monitoring efforts before 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 previous 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 Lion Bay 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 Lion Bay are probably not 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 Refuge coast (Camden Bay, Kaktovik/Jago Lagoon, Beaufort Lagoon, and Pokok Bay) in 1988 and 1989 (Fruge et al. 1989; Palmer and Dugan 1990).

Humpback whitefish are a targeted species in the fall Colville River subsistence fishery and are taken incidentally in the summer fishery (Moulton 1994, 1995, 2001, 2003; Moulton and Field 1988, 1991, 1994; Moulton and Seavey 2004; Moulton et al. 1986; Nelson et al. 1987).

Salmon (Oncorhynchus spp.)

Although five species of Pacific salmon have been reported from the Alaska Beaufort Sea, three of these—Chinook, sockeye, and coho salmon—are extremely rare and no known spawning stocks have been identified in the region (Craig and Haldorson 1986, Fechhelm and Griffiths 2001; Stephenson 2006). There is circumstantial evidence that pink salmon (Iñupiaq name = Amaqtuuq) may spawn in the Sagavanirktok River. Several spawned-out individuals were found upriver near the West Channel bridge (Griffiths et al. 1983). However, no actual spawning sites or activities have ever been reported. There are also small runs of chum salmon in the Colville River drainage. Bendock (1979) reported taking 35 chum salmon (Iñupiaq name = Iqalugruaq) in the lower reaches of the river and indicated that spawning occurred in the lower river from mid-August–mid-September. In recent years, smolts have been caught in the lower delta (Moulton 2001). Although chum salmon are taken in the fall subsistence fishery, they constitute only a minor portion of total catch (Moulton et al. 1992, 1993; Moulton 1994, 1995, 2001, 2003; Moulton and Field 1988, 1991, 1994; Moulton and Seavey 2004). There is no reported evidence that chum salmon spawn in the Sagavanirktok River. In addition, no juvenile salmon have ever been collected in the Prudhoe Bay area (Fechhelm et al. 2009).

Because of their relatively low numbers, Pacific salmon have not been a major environmental concern with regard to oil industry development in the Prudhoe Bay area. There is some evidence that the occurrence of salmon has been increasing over the past 20 years (BLM 2008) and, in recent years, there has been some conjecture that global warming could allow southern stocks from the Bering Sea to expand northward into Arctic waters where they might establish spawning populations (Babaluk et al. 2000; Stephenson 2006). Babaluk et al. (2000) note that changes in the distribution and abundance of salmon may be useful indicators of climate change on the Beaufort Sea.

Other Coastal Marine Species

Fourhorn sculpin (Iñupiaq name = Kayanuq), Arctic flounder (Iñupiaq name = Nataagnaq/ Puyyagiaq), and Arctic cod (Iñupiaq name = Uugaq) have a near circumpolar distribution and are regularly found in nearshore coastal waters during summer in virtually all areas of the Beaufort Sea (Craig and Haldorson 1981; Griffiths and Gallaway 1982; Critchlow 1983; Griffiths 1983; WCC 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; Palmer and Dugan 1990; Glass et al. 1990; LGL 1990, 1991, 1992, 1993b, 1994a, 1994b; Reub et al. 1991; Griffiths et al. 1995, 1996, 1997; Underwood et al. 1995; Fechhelm et al. 1996). Saffron cod are found in brackish and marine waters of the Beaufort Sea east to Bathurst Inlet in Canada

(Walters 1955). They frequently enter rivers and may go considerable distances upstream (Morrow 1980a). All of these species generally inhabit deeper waters during colder months of the year and move shallower during the summer months to make use of nearshore production. Specifically, they are considered abundant in Lion Bay (LGL 2000b) during summer months. LGL (2000b) found that fourhorn sculpin were the second most frequently caught fish after Arctic cisco. In turn, saffron cod were more abundant that Arctic cod and Arctic flounder, but all were consistently caught in the lagoon.

Of these species, cod are an important subsistence food item, and they comprise a part of the diets of numerous marine mammals, birds, and fish, and are therefore considered to be a primary component of the Arctic marine food chain (Craig and Haldorson 1981; Craig et al. 1982; Frost and Lowry 1980; Finley and Evans 1983; Bradstreet et al. 1986; Hobson and Welch 1992).

3.2.4 Birds

This section does not include Threatened and Endangered Species. See Section 3.2.7 for the description of those listed species within the Project area, which include Yellow-billed Loon, Spectacled Eider, and the Steller Eider. The Point Thomson region, on the Beaufort Sea coast between the Badami Development and the Canning River near the western border of the Refuge, has been the site of bird research periodically since the early 1980s. Wright and Fancy (1980) and WCC and ABR (1983) conducted the first limited ground-based studies of birds in the area. In the immediate vicinity of the Project infrastructure, a 2-year study of breeding birds, focusing primarily on shorebirds, was conducted in 2001 and 2002 (Rodrigues 2002a, 2002b). Other bird studies have been conducted either at inland sites south of the Point Thomson region; the Yukon Gold exploratory ice pad (TERA 1993a) and the Pingo-X exploratory area (Schick et al. 2003); or farther to the east near the Badami Development and the Kadleroshilik River (TERA 1994). Aerial surveys for waterfowl (including eiders) and other marine birds have been conducted in the nearshore and tundra habitats of the Point Thomson region sporadically since the mid-1970s by LGL (Noel et al. 1999a, 1999b, 1999c, 2000a, 2002a, unpublished data); TERA (1999, 2000, 2001, 2002a, 2002b); the U.S. Fish & Wildlife Service (USFWS) (Fischer and Larned 2004; Dau and Larned 2007); and the U.S. Geological Survey-Biological Resource Discipline (USGS-BRD) (Petersen et al. 1999; Flint et al. 2001; Lanctot et al. 2001). The area between the Canning River and the Sagavanirktok River also has been surveyed annually for eiders and other birds during the North Slope eider breeding-population survey (Larned et al. 1993–2006) and the annual waterfowl breeding-pair survey (Mallek and King 2000; Mallek 2001; Mallek et al. 2002, 2003, 2004, 2005, 2006a, 2006b). Since 2007, these two aerial surveys have been combined into a single, annual survey for eiders and other breeding waterbirds (Larned et al. 2007, 2008, 2009).

In the Refuge, the border of which lies approximately 2 miles (3.2 kilometers) east of the Project infrastructure, research about bird populations and habitats has been conducted at many sites since the early 1980s, first as part of basic refuge studies and later as part of the 1002 Study Area baseline studies. The studies in 1979–1980 included breeding-bird and habitat assessments near the Canning River, as well as bird use of shorelines in the Canning River

Delta (Martin and Moitoret 1981). Later, the 1002 Study Area studies from 1984–1986 included breeding-bird surveys at several established plots across the Refuge (Garner and Reynolds 1986). Since 2003, breeding-bird studies have been continued in the Refuge at sites near the Canning and Jago rivers (Kendall et al. 2003, 2007; Kendall and Brackney 2004; Kendall and Villa 2005, 2006; Brown et al. 2007; Liebezeit et al. 2009) and on barrier islands offshore (Kendall 2005).

Birds occurring in the Point Thomson region can be divided into four functional or habitat-related species groups: waterfowl and other waterbirds, shorebirds, ptarmigan, and passerines, and predatory birds (raptors, seabirds, and ravens). General abundance, distribution, and habitat use are addressed below for the species in each group, largely on the basis of information from baseline studies at Point Thomson and elsewhere on the North Slope (Spindler 1979; Martin and Moitoret 1981; WCC and ABR 1983; Garner et al. 1986; Garner and Reynolds 1986; Moitoret et al. 1996; Johnson and Herter 1989; Murphy and Anderson 1993; TERA 1993a, 1993b; Noel et al. 1999a, 2000; Johnson et al. 2000; Rodrigues 2002a, 2002b; Kendall et al. 2003, 2007; Kendall and Brackney 2004; Kendall and Villa 2005, 2006). Most of these studies focused on study areas affected by current or future oil development, but they also included studies conducted in the Refuge since the late 1970s. Scientific and common names for all 73 bird species recorded in the Point Thomson region are provided in Table 3-24.

TABLE 3-24: COMMON, SCIENTIFIC, AND INUPIAQ NAMES, STATUS, AND RELATIVE ABUNDANCE OF BIRDS OCCURRING ON THE ARCTIC COASTAL PLAIN OF ALASKA AND THOSE SPECIES RECORDED IN THE POINT THOMSON REGION,[1] ALASKA

Common Name	Scientific Name	Inupiaq Name	Status[2,3]	Relative Abundance[4]
Greater White-fronted Goose	*Anser albifrons*	niblivik	Breeder+	Common
Emperor Goose	*Chen canagica*	mitilugruaq	Visitant	Accidental
Snow Goose	*Chen caerulescens*	kafuq	Breeder+	Uncommon
Brant	*Branta bernicla*	niblinbaq	Breeder*	Common
Canada Goose	*Branta canadensis*	iqsrabutilik	Breeder*	Common
Cackling Goose	*Branta hutchinsii*	iqsrabutilik	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
Willow Ptarmigan	*Lagopus lagopus*	aqargiq, nasaullik	Resident*	Uncommon
Rock Ptarmigan	*Lagopus mutus*	niksaaktufiq	Resident*	Common
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	Breeder+	Uncommon
Horned Grebe	*Podiceps auritus*		Visitant	Casual
Red-necked Grebe	*Podiceps grisegena*	aqpaqsruayuuq, sublitchauraq	Breeder	Uncommon
Short-tailed Shearwater	*Puffinus tenuirostris*		Visitant+	Uncommon
Bald Eagle	*Haliaeetus leucocephalus*	tifmiaqpak	Visitant	Casual
Northern Harrier	*Circus cyaneus*	papiktuuq	Visitant+	Uncommon

Common Name	Scientific Name	Inupiaq Name	Status[2,3]	Relative Abundance[4]
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
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
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*		Breeder+	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
Wilson’s Snipe	*Gallinago delicata*	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

Common Name	Scientific Name	Inupiaq Name	Status[2,3]	Relative Abundance[4]
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	*Bubo scandiacus*	ukpik	Breeder+	Uncommon
Northern Hawk Owl	*Surnia ulula*	niaquqtuabruk	Visitant	Casual
Short-eared Owl	*Asio flammeus*	nipaixuktaq	Breeder+	Uncommon
Northern Flicker	*Colaptes auratus*		Visitant	Casual
Common Raven	*Corvus corax*	tulugaq	Resident+	Uncommon
Horned Lark	*Eremophila alpestris*	nagrulik	Visitant+	Casual
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*	tulugagnasrugruk	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
European Starling	*Sturnus vulgaris*		Visitant	Accidental
Yellow Wagtail	*Motacilla flava*	piibaq, misiqqaaqauraq	Breeder+	Common
American Pipit	*Anthus rubescens*	piibavik, putukiuxuk	Visitant	Rare
Orange-crowned Warbler	*Vermivora celata*		Visitant	Casual
Yellow Warbler	*Dendroica petechia*	sunaqpaluktuniq	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

Common Name	Scientific Name	Inupiaq Name	Status[2,3]	Relative Abundance[4]
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	*Acanthis flammea*	saksakiq	Breeder+	Uncommon
Hoary Redpoll	*Acanthis hornemanni*	saksakiq	Breeder	Uncommon

Notes:
Sources: Kessel and Gibson (1978); Wright and Fancy (1980); Martin and Moitoret (1981); WCC and ABR (1983); Nickles et al. (1987); Field et al. (1988); Johnson and Herter (1989); TERA (1993a, 1993b); Hohenberger et al. (1994); Noel et al. (1999a, 1999b, 1999c, 2000a); Rodrigues (2002a, 2002b). Common and scientific names follow AOU Checklist of North American Birds (1983 and supplements 35–50) and Inupiaq names follow Webster and Zibell (1970); MacLean (1980); Norton et al. (1993); Kaplan (1986 personal communication).

[1] The Point Thomson region is roughly defined as the area between the Badami development and the Canning River; the region extends offshore to encompass the coastal lagoons and barrier islands, and inland a distance of 5 miles (8 kilometers).

[2] Status on the Arctic Coastal Plain (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 non-breeding species; also, in fall, one not directly en route between breeding and wintering ranges

[3] Status in the Point Thomson region:
* = Confirmed as breeder in Point Thomson region
+ = Observed in Point Thomson region, but not confirmed as breeding

[4] Abundance on the Arctic Coastal Plain:
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

3.2.4.1 Breeding

Johnson and Herter (1989) estimated that approximately 10 million birds of more than 240 species occur in the Beaufort Sea region of Alaska. Nearly all bird use on the ACP of Alaska is concentrated in the summer months (May–September) when snow-free nesting habitats, forage (vegetation and insects), and open water are available. Breeding occurs both on the mainland tundra areas and on offshore barrier islands. Waterfowl and seabirds are the primary breeders on the offshore islands and all species groups nest on the mainland tundra. The maximum number (13) of bird species recorded as breeding (that is, nests were found) on study plots in the vicinity of the Project infrastructure was at the lower end of the range (7–26) for similar plot-based studies that have been conducted elsewhere in the ACP (Table 3-25). Rodrigues (2002b) attributed the lower breeding diversity for birds at Point Thomson to the drier nature of most habitats there compared with other North Slope sites where bird studies have been conducted. Details about the nesting and brood-rearing habits, and the habitat preferences of breeding birds in the Project region are discussed below under the sections for the four bird species groups that occur in the region.

TABLE 3-25: NESTING DENSITY OF BIRDS IN THE POINT THOMSON REGION AND ADJACENT AREAS ON THE ARCTIC COASTAL PLAIN, ALASKA

Species	Location/Density[1]											
	Point Thomson			Yukon Gold	Canning River Delta				Badami	Kadleroshilik	Sagavanirktok River Delta	Point McIntyre Reference Area
	1983	2001[2]	2002	1993	1979–1980	2002	2003	2004–2006	1994	1994	1981	1981–1992
Red-throated Loon								1.7	0.8			0.3
Pacific Loon			1.0			2.8	4.9	1.7		2.6		3.9
Greater White-fronted Goose										0.8		2.8
Canada Goose	3.9	0/1.8								3.4		0.3
Northern Pintail							4.9	0.4				0.3
Spectacled Eider										0.8		0.5
King Eider		3.6/3.6	2.1		2.1		9.8	2.2	1.8	1.8	4.4	3.4
Common Eider	3.9							0.9				
Unidentified Eider		0/1.8										
Long-tailed Duck	3.9	1.8/0	1.0	0.8	2.1	2.8			0.8	3.4	4.4	3.4
Willow Ptarmigan												0.3
Rock Ptarmigan		1.8/0			3.9			0.4	0.8			0.8
Black-bellied Plover									0.8	1.8	4.4	1.6
American Golden Plover		3.6/0	7.5	2.6	3.9			0.4	7.0	4.4	8.5	7.0
Sanderling												0.3
Semipalmated Sandpiper		31.3/20.5	28.0	6.0	25.9	43.2	32.4	36.3	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	25.9/24.1	28.0	18.9	31.9	20.2	46.9	40.1	23.3	31.1	4.4	22.5
Dunlin		1.8/9.3	5.4		8.0	14.5	8.0	10.4	8.5	10.4		19.4
Stilt Sandpiper			1.0			5.7	6.5	10.4	3.4	3.4		1.8
Buff-breasted Sandpiper		3.6/5.4			6.0						4.4	2.3
Long-billed Dowitcher	7.8	1.8/1.8	3.4					0.4	1.8			1.0
Red-necked Phalarope		3.6/0	14.0	1.8	14.0	14.5	6.5	20.7	2.6	8.5	4.4	2.3

Species	Location/Density[1]											
	Point Thomson			Yukon Gold	Canning River Delta				Badami	Kadleroshilik	Sagavanirktok River Delta	Point McIntyre Reference Area
	1983	2001[2]	2002	1993	1979–1980	2002	2003	2004–2006	1994	1994	1981	1981–1992
Red Phalarope	7.8	3.6/0	1.0	3.4	47.7	54.6	24.3	12.5	6.0	19.9	13.0	17.6
Parasitic Jaeger								0.9				0.3
Lapland Longspur	62.2	53.6/62.9	60.3	38.1	71.5	37.3	48.7	71.2	90.7	64.8	47.4	38.3
TOTAL DENSITY	167.1	138.0/131.3	153.3	73.3	216.9	195.6	192.9	210.7	192.9	180.3	134.2	166.3
Waterfowl/Loons	11.7	7.3/5.4	4.1	0.8	4.2	5.6	19.6	6.9	3.4	12.7	8.8	14.8
Shorebirds	93.2	75.4/62.9	88.6	32.6	137.3	152.7	124.6	131.3	97.4	102.8	78.0	111.9
Passerines & Other Birds	62.2	55.4/62.9	61.3	38.1	75.4	37.3	48.7	72.5	91.5	64.8	47.4	39.6
Number of Species	8	13/8	12	7	11	9	10	13	15	15	11	26

Notes:

1 Densities are reported in nests/mi^2

2 Densities for reference and treatment plots are shown (reference/treatment). Treatment plots were placed adjacent to the proposed infrastructure at Point Thomson and reference plots were placed at least 0.6 mile (1 kilometer) from any proposed infrastructure.

3 Methods varied among studies, but all involved nest searches within transects or plots; for multiple-year studies, average densities are presented, except for Point Thomson in 2001 and 2002 where plot locations differed between years and Canning River Delta during 2002–2003 when fewer plots were surveyed than in 2004–2006

3.2.4.2 Migration

The migration periods, particularly in fall (August–September) are particularly important periods for many bird species, especially shorebirds and waterfowl, such as Snow Geese (Kendall 2006), that may stage in large numbers within the Refuge. Almost all bird species that use the Point Thomson area migrate to the region from wintering areas farther south; only a few species overwinter in the area when food resources are scarce. Relatively few studies have been conducted to comprehensively document species occurrence, abundance, and movements along the ACP during both spring and fall migration, and only two studies have monitored migration in the Point Thomson region (Martin and Moitoret 1981; WCC and ABR 1983).

Martin and Moitoret (1981) observed migration in the Canning River Delta area during both spring and fall in 1980 and identified Brant, eiders, Long-tailed Duck, Northern Pintail, and scoters as the primary species moving past the delta. Spring migration occurred over a short period and observations were dominated by Brant flying eastward; Long-tailed Ducks and eiders were thought to be flying offshore out of sight of the observers (Martin and Moitoret 1981). Fall migration occurred over a more protracted period and again featured peaks of migration of Long-tailed Ducks and Brant flying west, as well as Greater White-fronted Geese, Canada Geese, and ducks flying east along the coast. Long-tailed Ducks migrated over offshore waters and along the barrier islands and stopped frequently in nearshore lagoons to rest and feed. In contrast, Brant tended to fly low along the mainland shoreline, around Brownlow Point, and then along the coast to the west, but they also stopped and fed in the saline meadows and coastal tundra along the mainland and Brownlow Lagoon shorelines. Shorebird migration was more sporadic, with small flocks stopping at various places (particularly saline meadows) along the coast to feed before moving on (both eastward and westward movements of shorebirds were seen in fall).

A subsequent study of migration in the Project area was conducted by WCC and ABR (1983) that reported results similar to those recorded on the Canning River Delta. Spring and fall migration was dominated by movements of large numbers of Brant; other abundant species in fall were Long-tailed Duck, Arctic tern, and glaucous gull. Coastal brackish marshes near Point Thomson were important habitats for migrating birds during both spring and fall.

The westward and eastward movements of birds during both spring and fall migration are a feature of the two major migration routes followed by birds to reach the ACP: along the western coast of Alaska (the Pacific Flyway), and following the Mackenzie River Valley in Canada (the central North American Flyway). Different species use each route, depending upon the location of their wintering grounds.

The Refuge also is an important fall-staging area for Snow Geese from the Western Canadian Arctic Population, with upwards of several hundred thousand Snow Geese migrating from Canada to the Refuge, where they remain and feed for up to two weeks before moving eastward and down the Mackenzie River Valley (Hupp et al. 2002; Kendall 2006). A few band returns of Snow Geese marked at breeding colonies in Alaska indicate that at least a small number of Snow Geese from Alaska and Russia likely join these staging flocks on the Refuge (Ritchie et al. 2009), but most Snow Geese staging on the Refuge do not migrate past the Point

Thomson area. The major fall-staging areas for Snow Geese on the Refuge vary annually, but tend to be concentrated in the Hulahula River area, well to the east of Point Thomson (Hupp et al. 2002; Kendall 2006).

Migration of birds along the barrier islands and in the offshore waters of the Beaufort Sea is less well understood than migration along the coastlines, but a recent radar-based study at Northstar Island, an offshore drilling island northeast of Prudhoe Bay, documented large-scale movements of eiders (primarily king and common) during fall migration, as well as movements of other species (Day et al. 2005). Movements continued throughout September and into October when sea ice began to form. Most eiders moved rapidly past the island in a northwesterly direction, whereas non-eiders moved in a variety of directions and at slower speeds. Non-eider species were primarily loons, ducks (mostly Long-tailed Duck), shorebirds, and gulls. Use of anti-collision lighting on infrastructure at the island had mixed results in that it apparently slightly increased avoidance of the island by migrating eiders, but appeared to attract other species (Long-tailed Duck and gulls).

3.2.4.3 Species of Conservation Concern

Of the 73 bird species recorded in the Project region, 24 species currently are considered priority species by the state for conservation (Table 3-26). This group of 24 species does not include the two federally-listed species (spectacled eider, Steller's eider) and the one candidate species (yellow-billed loon) that are treated separately below under Section 3.2.7, Threatened and Endangered Species. Of these 24 species, nine species (four waterfowl, one loon, and four shorebirds) have been confirmed to breed in the Project region. Seven of the 24 species are known to breed elsewhere on the ACP, but have not been recorded breeding at Point Thomson, and the remaining eight species are classified as migrants or visitants in the Project region.

The 24 species of conservation concern recorded in the Project region are not federally listed under the ESA, but concern by the USFWS (2008a) about their conservation status has been raised in recent years with the introduction of programs by management agencies, working groups, and conservation organizations to assess the conservation status of birds more broadly than is done under the ESA (ADF&G 1998, 2006; Boreal Partners in Flight Working Group [BPIFWG] 1999; Kushlan et al. 2002; American Shorebird Group [ASG] 2004; Rich et al. 2004; BLM 2005b; Stenhouse and Senner 2005; ABC and NAS 2007; AKNHP 2007; USFWS 2004, 2008a). In general, the 24 species are of conservation concern because their breeding populations are small, isolated, and/or declining and/or there are known population threats during the breeding and/or non-breeding seasons. For the purposes of this Environmental Report (ER), to be considered a priority species for conservation, a species had to be present on at least two state or federal agency's species-of-concern lists. This rule was used to reduce the possibility of bias in the listings of species by only a single state or federal agency, working group, or conservation organization.

TABLE 3-26: BIRD SPECIES OF CONSERVATION CONCERN RECORDED IN THE POINT THOMSON REGION AND LISTING STATUS BY STATE OR FEDERAL AGENCY OR PRIVATE CONSERVATION ORGANIZATION

Species[1] (Scientific Name)	USFWS[2]	BLM[3]	ADF&G[4]	Audubon Alaska[5]	ABC and National Audubon[6]	AKNHP[7]	ASG and USSCP[8]	BPIFWG and PIF[9]	NAWCP[10]
Brant (*Branta bernicla*)	—	Sensitive species	—	Species at risk	—	Vulnerable	—	—	—
King Eider (*Somateria spectabilis*)	—	Sensitive species	Priority species for conservation	Species at risk	—	Vulnerable	—	—	—
Common Eider (*Somateria mollissima ssp. v-nigrum*)	—	—	Priority species for conservation	Species at risk	—	Imperiled	—	—	—
Surf Scoter (*Melanitta perspicillata*)	—	Sensitive species	Priority species for conservation	—	—	—	—	—	—
Black Scoter (*Melanitta nigra*)	—	Sensitive species	Priority species for conservation	—	—	—	—	—	—
Long-tailed Duck (*Clangula hyemalis*)	—	Sensitive species	Priority species for conservation	Species at risk	—	—	—	—	—
Red-throated Loon (*Gavia stellata*)	Species of conservation concern	Sensitive species	Priority species for conservation	Species at risk	—	Imperiled-vulnerable	—	—	—
Golden Eagle (*Aquila chrysaetos*)	—	—	Priority species for conservation	Species at risk	—	—	—	—	—
Gyrfalcon (*Falco rusticolus*)	—	—	Priority species for conservation	Species at risk	—	Vulnerable	—	Priority species for conservation (Boreal PIF only)	—
Peregrine Falcon[11] (*Falco peregrinus ssp. tundrius*)	Delisted and species of conservation concern	Sensitive species	Priority species for conservation and species of special concern	Species at risk	—	Imperiled	—	—	—
American Golden-Plover (*Pluvialis dominica*)	—	—	Priority species for conservation	Species at risk	Declining species	—	Species of high concern	—	—
Whimbrel (*Numenius phaeopus*)	Species of conservation concern	—	Priority species for conservation	Species at risk	—	—	Species of high concern	—	—
Bar-tailed Godwit (*Limosa lapponica*)	Species of conservation concern	—	Priority species for conservation	Species at risk	Declining species	—	Species of high concern	—	—
Ruddy Turnstone (*Arenaria interpres*)	—	—	Priority species for conservation	Species at risk	—	—	Species of high concern	—	—
Red Knot (*Calidris canutus*)	Species of conservation concern	Sensitive species	Priority species for conservation	Species at risk	Declining species	—	Species of high concern	—	—

Species[1] (Scientific Name)	USFWS[2]	BLM[3]	ADF&G[4]	Audubon Alaska[5]	ABC and National Audubon[6]	AKNHP[7]	ASG and USSCP[8]	BPIFWG and PIF[9]	NAWCP[10]
Sanderling (*Calidris alba*)	—	—	Priority species for conservation	Species at risk	Declining species	—	Species of high concern	—	—
Western Sandpiper (*Calidris mauri*)	—	—	Priority species for conservation	—	Vulnerable species	—	Species of high concern	—	—
Dunlin (*Calidris alpina ssp. articola*)	Species of conservation concern	—	Priority species for conservation	Species at risk	—	—	Species of high concern	—	—
Stilt Sandpiper (*Calidris himantopus*)	—	—	—	—	Declining species	Vulnerable	—	—	—
Buff-breasted Sandpiper (*Tryngites subruficollis*)	Species of conservation concern	Sensitive species	Priority species for conservation	Species at risk	Highest national concern	Imperiled	Highly imperiled	—	—
Arctic Tern (*Sterna paradisaea*)	Species of conservation concern	—	Priority species for conservation	—	—	—	—	—	High conservation status
Black Guillemot (*Cepphus grylle*)	—	Sensitive species	—	—	—	Imperiled	—	—	—
Snowy Owl (*Bubo scandiacus*)	—	—	Priority species for conservation	—	—	Vulnerable	—	—	—
Short-eared Owl (*Asio flammeus*)	—	—	Priority species for conservation	Species at risk	Declining species	—	—	Priority species for conservation (National PIF only	—

Notes:

1 Only species with low population numbers or similar population threats (e.g., declining populations; restricted breeding, staging, or wintering areas), or both, are listed. Federally listed threatened and endangered species, including the Yellow-billed Loon, are considered separately in Section 3.2.7, Threatened and Endangered Species.

2 U.S. Fish and Wildlife Service: Birds of Conservation Concern (non-game birds) (USFWS 2008).

3 Bureau of Land Management (BLM): Alaska Threatened, Endangered, and Sensitive Species List (BLM 2005b).

4 Alaska Department of Fish and Game: Species of Special Concern (ADFG 1998) and Comprehensive Wildlife Conservation Strategy (ADF&G 2006).

5 Audubon Alaska Watchlist 2005 (Stenhouse and Senner 2005).

6 The American Bird Conservancy and National Audubon Society: U.S. Watch List of Birds of Conservation Concern (ABC and NAS 2007).

7 Alaska Natural Heritage Program: Birds Tracking List (AKNHP 2007), state listings only—the highest conservation ranking (for either the breeding or non-breeding season) is shown; Secure, Apparently Secure, and Vulnerable/Apparently Secure rankings are not shown.

8 Alaska Shorebird Group: Alaska Shorebird Conservation Plan (ASG 2004) and U.S. Shorebird Conservation Plan: High Priority Shorebirds (USSCP 2004).

9 Boreal Partners in Flight Working Group: Priority Species of Concern List (landbirds) (BPIFWG 1999) and Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004).

10 North American Waterbird Conservation Plan (Kushlan et al. 2002).

11 The *tundrius* subspecies of Peregrine Falcon was delisted and removed from endangered species status (USFWS 2006); the entire species is of conservation concern (USFWS 2008).

ABC = American Bird Conservancy
ADF&G = Alaska Department of Fish and Game
AKNHP = Alaska Natural Heritage Program
ASG = American Shorebird Group
BLM = Bureau of Land Management
BPIFWG = Boreal Partners in Flight Working Group
NAWCP = North American Water Bird Conservation Plan
PIF = Partners in Flight
USFWS = United States Fish and Wildlife Service
USSCP = United States Shorebird Conservation Plan

3.2.4.4 Waterfowl and Other Waterbirds

The Project region supports at least 19 species of waterfowl (Tundra Swan, geese, eiders, and other ducks) and four species of other waterbirds (loons). Of these 23 species, eight have been found to breed in the area. Five of these eight breeding species (63 percent) currently are considered priority species for conservation by ADF&G (see Section 3.2.4 Birds).

Tundra Swan

Tundra Swans are common breeders on the ACP and have been recorded breeding in the Project region (Johnson and Herter 1989; Byrne et al. 1994; Johnson et al. 1999a). Tundra Swans have a number of attributes that make them important indicators of regional ecosystem health on the North Slope: they are long-lived and monogamous, they often nest at the same location year after year (Limpert and Earnst 1994) and, because they are sensitive to human disturbance, changes in their activities and distribution (in the absence of other explanatory factors) can provide a measure of the effects of development projects (King 1973; Ritchie et al. 1990). 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 Project region supports moderate numbers of Tundra Swans compared with other areas in northern Alaska (Rothe and Hawkins 1982; Ritchie and King 2000).

Tundra Swans occur in the Project area from May–September (WCC and ABR 1983). Although the first swans arrive while the tundra is largely snow-covered (mid-May), most arrive one to two weeks later (Hawkins 1986; Ritchie and King 2000). As snow melts, pairs move to breeding territories and begin nesting by early June. After eggs hatch in early July, family groups remain together, but often range widely to find food (Johnson and Herter 1989). While the young are growing and cannot fly, the adults also become flightless (undergo wing molt) for about three weeks. During this flightless period, swan broods are sensitive to disturbance. By mid- to late September, both adults and young can fly and family groups begin preparing for fall migration. In the Colville River Delta area, non-breeding swans form large staging flocks (greater than 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, immediately to the east of Point Thomson. Fall staging on the ACP usually takes place during early to mid-September (Rothe et al. 1983; Smith et al. 1994; 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 Project region, but nesting density (0.05 nest per square mile [0.02 nest per square kilometer]) (Byrne et al. 1994) appears to be lower there than has been recorded to the west (0.02–0.10 nest per square mile [0.01–0.04 nest per square kilometer] in the Kuparuk oil field, 0.08–0.21 nest per square mile [0.03–0.08 nest per square kilometer] on the Colville River Delta, and 0.23 nest per square mile [0.09 nests per square kilometer] on the Sagavanirktok River Delta [Ritchie and King 2000]). Only a few swan nests have been found in the Project area. During ground searches in the area, WCC and ABR (1983) found two Tundra Swan nests, both associated with the lakes and ponds habitat type. Other swans were seen in June in wet strangmoor habitats (WCC and ABR 1983).

Although Rodrigues (2002a, 2002b) observed swans in the Project area, he found no swan nests in his study plots in either 2001 or 2002. The limited breeding of swans in the Project area is reflective of the low density of swans in the larger region. 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 only seven swans (and no nests) were seen between Mikkelsen Bay and the Staines River. Tundra Swans are somewhat more abundant to the east in the Refuge, although their densities in the Canning River area seem to have declined in recent years (Larned et al. 2006).

No surveys have been conducted in the Project area specifically for brood-rearing swans, but LGL et al. (1999) reported densities of 0.28 swan per square mile (0.11 swan per square kilometer) during aerial surveys of tundra transects in the Project 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 Project 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 were noted during two aerial surveys).

Tundra Swans use a variety of different habitats on the North Slope during the breeding season. Although specific studies of the habitats used by swans in the Project area have not been conducted, other studies in the larger region provide information about important habitats for breeding swans. In the Kuparuk oil field, Tundra Swans are frequently found nesting adjacent (less than 0.04 mile [0.06 kilometer]) to larger ponds and lakes, often those supporting emergent vegetation such as sedges (primarily water sedge [*Carex aquatilis*]) and pendant grass (*Arctophila fulva*) (Stickney et al. 2002; Anderson et al. 2003). On the Canning River Delta, the most common nesting habitat used by Tundra Swans was graminoid-marsh (dominated by *Arctophila fulva* and *Carex aquatilis*), and nests were usually less than 0.6 mile (1 kilometer) from lakes (Monda et al. 1994). Brood-rearing Tundra Swans prefer aquatic habitats because they provide food and escape cover, especially for the young. 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).

Geese

Five species of geese (Greater White-fronted Goose, Canada Goose, Cackling Goose, Brant, and Snow Goose) regularly nest on the ACP, and at least two species (Canada Goose and Brant) have been recorded as nesting in the Project region (Johnson and Herter 1989; WCC and ABR 1983; Rodrigues 2002a, 2002b) (Tables 3-24 and 3-25). 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.

Greater White-Fronted Goose

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 one to two weeks, usually by late May (Rothe et al. 1983; Johnson and Herter 1989). Eggs hatch in late June and early July. Before the young can fly, adults (breeding and non-breeding) molt and are flightless for two to three 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 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 Project region, but were not recorded as nesting by WCC and ABR (1983), Wright and Fancy (1980), or Rodrigues (2002a, 2002b). 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 high density (15.0 birds per square mile [6 birds per square kilometer]) of geese seen during aerial surveys in August and September (LGL et al. 1999). Overall, numbers of Greater White-fronted Geese recorded during annual breeding-pairs surveys across the ACP between 1992–2008 indicate a positive population trend (+104 percent) for this species, and densities have increased during this period around the Shaviovik River Delta west of Point Thomson (Larned et al. 2008).

Canada Goose/Cackling Goose

With the recent splitting of the Canada Goose into several species, it is unclear where each species occurs on the ACP (the two forms were not separated in the earlier studies); therefore, for this discussion, we will simply use the Canada Goose terminology. 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 Project region, the Canada Goose is the primary nesting goose species (Wright and Fancy 1980; WCC and ABR 1983; Rodrigues 2002a, 2002b) and has been commonly observed during the breeding season (WCC and ABR 1983; Rodrigues 2002a, 2002b). Wright and Fancy (1980) found two Canada Goose nests, one in each of their plots (drilling site south of Point Gordon and the control site south of Point Sweeny). Eight Canada Goose nests were located during ground searches in the Project area in 1983, all in lakes and ponds habitat types (WCC and ABR 1983). The estimated nesting density (3.9 nests per square mile [1.5 nests per square kilometer]) in the Project area was the highest recorded for study sites from Point Thomson to the Prudhoe Bay area (Table 3-25). One Canada Goose nest was found in plots searched in 2001 at Point Thomson, but no nests occurred in plots in 2002 (Note: plot locations differed between years) (Rodrigues 2002a, 2002b). Canada Geese also use the Project area later in the season, and densities of 4.2 birds per square mile (1.6 birds per square kilometer) were recorded during aerial surveys of tundra transects in August–September 1998 (LGL et al. 1999).

Brant

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; Sedinger and Stickney 2000). Brant arrive on the coastal plain in early June and move to nesting colonies soon afterwards (Kiera 1979; 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.

In the central Beaufort Sea region, Brant nest primarily at two large colonies between the Staines and Colville rivers: on islands in the East Channel of the Colville River, and 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. Although Brant have been seen in the Project region from late May–late August (WCC and ABR 1983), nesting seems to be limited in the area. Brant have been found nesting (one nest) on an island in the Staines River Delta (Ritchie et al. 1991), but no nests were located during breeding-bird studies in 2001 or 2002 (Rodrigues 2002a, 2002b) at the Project site. One Brant nest was located at the Bullen Point Short-range Radar Site (SRRS) in 2002 (Ritchie et al. 2003). Small numbers of Brant have been recorded nesting at locations immediately west of the Project area, on the Shaviovik and Kadleroshilik River deltas, and on Tigvariak Island (Ritchie et al. 1990, 1991; Stickney et al. 1992, 1993). Nesting habitats used by Brant on the Colville River Delta included salt-killed tundra, aquatic sedge with deep polygons, brackish water, salt marsh, non-patterned wet meadow, and wet sedge–willow meadow (Johnson et al. 1999a).

No brood-rearing Brant have been recorded in the Project 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. 1999b). WCC and ABR (1983) reported small numbers (407 birds) of Brant in the Project 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 creeping alkali grass (*Puccinellia phryganodes*) and Hoppner sedge (*Carex subspathacea*), which are found only in saline (salt marsh) habitats (Kiera 1979). This habitat type is somewhat limited in the Project area, but small acreages of this type (less than 2 percent of the total mapped acreage) can be found near the Project site and at scattered locations between the Staines River and Mikkelsen Bay (see Section 3.2.2 Vegetation and Wetlands). The distance of these habitats from known breeding colonies limits their availability for brood-rearing flocks, although birds may use these areas during staging and migration. Large numbers of Brant were recorded moving westward through the Project area in 1983, during the staging and fall migration periods: 5,959 and 2,526 birds, respectively (WCC and ABR 1983). Whether these birds used salt-marsh habitats in the Project area is unknown. Small numbers of Brant (0.36 bird per square mile [0.14 bird per square kilometer]) were recorded during aerial surveys of lagoon transects in the Project area during August and September 1998 (LGL et al. 1999).

Snow Goose

Breeding phenology for Snow Geese is similar to that of other goose species already discussed. They arrive in coastal nesting areas in late May or early June and young hatch during late June, although onset of breeding can be affected by late snowmelt in nesting areas. 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 2000a; Ritchie et al. 2000). The three largest colonies recorded on the ACP occur on the Sagavanirktok, Ikpikpuk, and Kukpowruk River deltas (Ritchie and Burgess 1993; Noel et al. 2002b; Johnson 2000; Ritchie et al. 2000; Ritchie 2001). Each of these colonies has been growing rapidly since 2001, with the Ikpikpuk colony now having greater than 4,000 nests (Ritchie et al. 2009) and the Sagavanirktok colony on Howe Island having greater than 1,000 nests (McKendrick et al. 2008). No breeding colonies have been reported in the Project region (Wright and Fancy 1980; WCC and ABR 1983), but WCC and ABR (1983) did observe four Snow Geese during spring arrival in 1983 (early June) and, more recently, Rodrigues (2002b) observed Snow Geese in the Project area in 2001. The nesting colony closest to Point Thomson is at Howe Island on the Sagavanirktok River Delta. While this colony is currently expanding rapidly (McKendrick et al. 2008), in the 1990s, nesting was often disrupted by predators (Noel et al. 1999c, 2002a; Noel and Johnson 2001a, 2001b).

Brood-rearing Snow Geese have been seen in most years immediately west of the Project area, in the vicinity of the Shaviovik River Delta and on Tigvariak Island (Noel and Johnson 1997; Noel et al. 1999c). During autumn migration, large numbers (150,000–450,000) of Snow Geese stage on the eastern coastal plain of the Refuge for short periods in early–mid-September (Robertson et al. 1997; Hupp et al. 2002); this use of the Refuge's coastal plain by Snow Geese has been documented by more than 30 years of aerial surveys (Kendall 2006). The estimates of the number of geese in the Refuge, however, have been affected by differing methodologies over the years, and numbers within years could be affected by movements of geese between Alaska and Canada during staging (Kendall 2006). Use of the Project area by migrating or staging Snow Geese seems to be sporadic. In 1983, WCC and ABR (1983) did not record any Snow Geese during staging or fall migration in the Project area. More recently, however, Noel et al. (2002b) recorded 490 Snow Geese in the Eastern Lagoon (Pole Island to Brownlow Point) during aerial surveys of tundra and lagoon transects in the Project area in late July–August 2001, suggesting that some use of the area does occur.

Ducks

Ducks on the ACP of Alaska can be separated into three general groups: Arctic breeders (eiders and Long-tailed Duck); 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 (scoters and Common Goldeneye).

Of the 13 species of ducks recorded in the Project region, four are confirmed breeders: the Long-tailed Duck, and Spectacled, King, and Common eiders (Tables 3-24 and 3-25) (Wright and Fancy 1980; WCC and ABR 1983; TERA 1993a). Spectacled Eiders are discussed in Section 3.2.7, Threatened and Endangered Species. King Eiders were the most abundant eider seen during aerial surveys for eiders in the Project region (Byrne et al. 1994; TERA 1999, 2000, 2001, 2002a, 2002b). Northern Pintails are common, and probably do nest in the Project area, but no nests were found during nest searches by Wright and Fancy (1980), WCC and ABR (1983), or Rodrigues (2002a, 2002b). Other duck species could potentially be abundant in the Project 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 coastal beaches and on offshore barrier islands, but breeding pairs also have been recorded at inland sites in the Project region (TERA 1999, 2000, 2001, 2002), and nesting has been observed at Bullen Point (Ritchie et al. 2003), suggesting that Common Eiders may nest regularly in low numbers in inland areas. Common Eiders regularly nested on the barrier islands between Mikkelsen Bay and the Staines River, with a yearly average of 124 nests found among the barrier islands searched (Table 3-27). Of the seven major barrier islands in the Project region, Pole, Alaska, North Star and Duchess islands supported the most nesting Common Eiders. In 2002, USGS-BRD biologists found 33 Common Eider nests on five small, sand-spit islands just off the mainland in the Project area. Flint et al. (2002) hypothesized that use of these small islands by nesting eiders may not be annual, but occurred in 2002 because late sea-ice break-up conditions made open water available near these islands.

Like most waterbirds, ducks (including eiders) occur in the Project region between May and September, when tundra ponds are ice-free. Ducks arrive on the tundra in mid- to late May, begin nesting within one to two weeks, and depart by late August (Rothe et al. 1983; 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; 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).

TABLE 3-27: NUMBERS OF ACTIVE COMMON EIDER NESTS ON BARRIER ISLANDS IN THE POINT THOMSON REGION, 1970–2002

Year	Numbers of Nests							Total Nests	Source
	Pole	Belvedere	Challenge	Alaska	Duchess	North Star	Flaxman		
1970	7	5	0	1	0	1	3	17	Gavin data in Moitoret (1998)
1971	5	1	0	0	1	1	6	67	Gavin data in Moitoret (1998)
1972	50	4	0	1	0	1	7	63	Gavin data in Moitoret (1998)
1973	5	3	0	1	1	1	3	14	Gavin data in Moitoret (1998)
1974	4	2	0	0	0	0	2	8	Gavin data in Moitoret (1998)
1975	16	5	1	2	2	2	5	33	Gavin data in Moitoret (1998)
1976	64	10	4	12	0	2	0	92	Divoky (1978) in Moitoret (1998)
1979	61	—	—	2	9	—	0	72	Moitoret (1998)
1982	—	30	45	—	—	—	0	75	Moitoret (1998)
1983	141	1	17	44	11	6	2	222	Moitoret (1998)
1984	60	4	3	29	6	18	0	120	Moitoret (1998)
1985	215	—	11	41	21	15	2	305	Moitoret (1998)
1987	158	15	4	26	31	4	—	238	Moitoret (1998)
1988	162	7	9	38	27	17	—	260	Moitoret (1998)
1989	0	1	28	21	42	28	—	120	Moitoret (1998)
1998	—	—	18	24	112	13	5	172	Noel et al. (1999c)
2000	107	2	12	60	113	29	14	337	Noel et al. (2002c)
2001	0	0	2	28	41	20	0	91	Noel et al. (2002c)
2002	0	0	3	4	37	7	0	51	Flint et al. (2002); Noel et al. (2002d)
Mean	62.0	5.6	8.7	18.6	25.2	9.7	3.1	124.0	
SD	69.6	7.6	12.0	18.7	35.2	9.8	3.8	101.7	
n	17	16	18	18	18	17	16		

Note: in some years the number of failed nests found during nest searches may be large and are not reported here.
SD = Standard Deviation.
n = number of years island was searched for nests.
— = that island not surveyed that year.

Information about nesting habitats of ducks in the Project region is relatively sparse, but WCC and ABR (1983) found breeding pairs in moist and wet tundra habitats and lakes without emergent vegetation. Rodrigues (2002a, 2002b) found nesting King Eiders in wet sedge/moist sedge, dwarf shrub tundra complex, and in moist sedge, dwarf shrub/wet graminoid tundra complex habitats in both 2001 (two nests in each type) and 2002 (one nest in each type). Long-tailed Ducks also nested in moist sedge, dwarf shrub/wet graminoid tundra complex (one nest in 2002), and in moist sedge, dwarf shrub tundra (one nest in 2001). 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 Project region likely receive some use by ducks for nesting, brood-rearing, and foraging.

Aerial surveys for Long-tailed Ducks have been flown in the Project region sporadically since 1977 and the data acquired allow calculations of relative abundance (densities; birds per square mile or square kilometer) and distribution during the molting and post-molting periods (Noel et al. 1999a, 2000, 2001, 2002b; Petersen et al. 1999; Flint et al. 2001; Lanctot et al. 2001). During the molting and post-molting periods, Long-tailed Ducks are abundant along the mainland shore and in the lagoon system between the Staines River and Mikkelsen Bay, but are less commonly found on inland tundra (Figures 3-15 and 3-16). Relative abundance of Long-tailed Ducks varies among locations along the mainland shore and in the barrier island system of Lion Bay, and variability in flock sizes can be large within and among years. Along the mainland coast in the Project area, the shorelines between Point Thomson and Point Gordon received the greatest use during both the molting and post-molting periods (means = 530 birds per square mile [205 birds per square kilometer] and 223 birds per square mile [86 birds per square kilometer], respectively), whereas the shorelines to the east and west of this area were used less (Table 3-29). Within Lion Bay, the densities of Long-tailed Ducks varied both from east to west and between the molting and post-molting periods. During the molting period (Figure 3-15), 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 = 94 birds per square mile [36 birds per square kilometer). This same general west-east trend also was apparent during post-molting (Figure 3-16), but the peak abundance shifted westward in the lagoon to the Alaska Island to Flaxman Island area, and the mean density increased three-fold (to 283 birds per square mile [109 birds per square kilometer]). 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. Across all surveys, 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. During molting, the Flaxman Island to Brownlow Point area supported densities (mean = 896 birds per square mile [346 birds per square kilometer]), which were roughly twice the densities found in transects farther west (means ranged from 307–528 birds per square mile [119–204 birds per square kilometer]). In contrast, offshore transects (north of the barrier islands) had few Long-tailed Ducks during either the molting or post-molting period.

TABLE 3-28: MEAN DENSITIES OF LONG-TAILED DUCKS ON TRANSECTS DURING THE MOLTING AND POST-MOLTING PERIODS IN THE POINT THOMSON REGION, FROM AERIAL SURVEYS CONDUCTED FROM 1978–2002

Transect Location (Number)	Molting Period (approximately mid July–19 August)					Post-molting Period (20 August–30 September)				
	Overall Mean	SD[1]	Annual Range[2]	*N*[3]	Survey Range[4]	Overall Mean	SD[1]	Annual Range[2]	*N*[3]	Survey Range[4]
INLAND TRANSECTS										
Shaviovik Delta to Mikkelsen Bay (503)	9.2	7.8	6–16	3	<1–21	—[5]	—	—	0	—
Mikkelsen Bay to Point Gordon (502)	1.5	1.8	1–2	3	0–4	—	—	—	0	—
Point Gordon to Point Thomson (501)	2.4	5.2	0–9	4	0–15	19.3	6.0	15–23	1	15–23
Point Thomson to Brownlow Point (500)	0	0	0	3	0	—	—	—	0	—
MAINLAND SHORE TRANSECTS										
Lion Point to Bullen Point (193)	142.1	165.5	52–279	7	2–785	24.1	25.3	6–66	5	1–87
Bullen Point to near Point Gordon (192)	322.8	251.7	105–474	7	23–1,077	179.4	190.7	8–208	5	8–607
Near Point Gordon to Point Thomson (191)	529.9	428.0	175–1,008	7	25–2,078	223.4	270.2	86–472	5	26–1,054
Point Thomson to Brownlow Point (190)	282.3	304.1	61–700	7	0–1,269	48.6	40.2	26–59	5	8–125
MID-LAGOON TRANSECTS										
Pole Island to Challenge Entrance (183)	4.6	17.3	0–38	13	0–101	63.0	151.7	0–148	6	0–499
Challenge Entrance to Alaska Island (182)	75.1	160.0	0–481	13	0–835	189.8	290.3	68–559	6	0–1,040
Alaska Island to Flaxman Island (181)	82.9	129.0	9–588	13	0–588	282.6	863.7	14–1,237	6	0–3,507
Flaxman Island to Brownlow Point (180)	94.0	105.4	0–264	13	0–474	148.1	328.0	11–646	6	0–1,134
NORTHERN MID-LAGOON TRANSECTS										
Pole Island to Challenge Entrance (604)	20.3	59.6	0–67	3	0–199	122.2	—	—	1	—
Challenge Entrance to Alaska Island (605)	29.6	49.2	7–79	3	0–171	287.7	—	—	1	—
Alaska Island to Flaxman Island (606)	31.3	54.8	5–99	3	0–189	4.9	—	—	1	—
Flaxman Island to Brownlow Point (607)	119.4	163.6	29–321	3	7–489	80.5	—	—	1	—
BARRIER ISLAND TRANSECTS										
Pole Island to Challenge Entrance (133)	528.8	546.8	32–1,781	13	3–2,302	882.2	1,129.8	125–1,510	6	34–3,914
Challenge Entrance to Alaska Island (134)	307.4	347.2	14–798	13	0–1,442	796.4	1,234.4	80–1,632	6	3–4,086
Alaska Island to Flaxman Island (135)	505.9	567.7	65–1,250	13	0–2,969	651.6	956.7	66–1,410	6	66–3,329
Flaxman Island to Brownlow Point (136)	896.3	1,129.4	220–3,572	13	2–5,182	739.4	1,088.6	19–1,851	6	19–3,798
OFFSHORE TRANSECTS										

Transect Location (Number)	Molting Period (approximately mid July–19 August)					Post-molting Period (20 August–30 September)				
	Overall Mean	SD[1]	Annual Range[2]	*N*[3]	Survey Range[4]	Overall Mean	SD[1]	Annual Range[2]	*N*[3]	Survey Range[4]
Pole Island to Challenge Entrance (63)	0.7	2.0	0–3	7	0–9	24.9	38.7	0–78	4	0–95
Challenge Entrance to Alaska Island (62)	4.1	12.4	0–30	7	0–60	22.5	37.7	3–60	4	0–119
Alaska Island to Flaxman Island (61)	15.7	39.1	0–91	7	0–171	8.4	15.3	1–23	4	0–46
Flaxman Island to Brownlow Point (60)	12.5	24.6	0–61	7	0–96	20.8	31.7	0–48	4	0–95

Notes:
Sources: Noel et al. (1999a, 2000, 2002b); Petersen et al. (1999); Flint et al. (2001).
[1] SD = Standard Deviation
[2] Range of annual mean counts.
[3] *N* = number of years of aerial surveys in each transect.
[4] Range of individual survey counts across all years (1–7 surveys flown each year).
[5] Dash indicates either that no survey was flown in that segment or that values could not be calculated from a single survey.
Density = birds/square mile(s)

The Long-tailed Duck is a species of conservation concern in Alaska by the ADF&G because of a relatively rapid population decline starting in the 1970s. USFWS has conducted annual waterfowl breeding-population aerial surveys on the ACP since 1986, and although the Long-tailed Duck population index has fluctuated annually, with the recent increases in numbers in 2008, the population is currently not considered to be declining significantly (Larned et al. 2009).

Because of a high mortality rate during the molt period in 2000, the USGS-BRD conducted a study to evaluate Long-tailed Ducks for the presence of viruses and viral diseases in the Beaufort Sea (Hollmen et al. 2003; Flint et al. 2003). The mortalities were found to be linked to an outbreak of an avian adenovirus; however, additional mortality was observed in 2001, when the virus prevalence was low, and the long-term effects of the virus are unknown.

Loons

Three species of loons—Yellow-billed, Pacific, and Red-throated—breed on the ACP. Yellow-billed Loons are discussed below in Section 3.2.7, Threatened and Endangered Species. Common Loon and two species of grebes are casual visitors or irregular breeders, respectively, on the ACP (Table 3-24). Based on the USFWS breeding-pair surveys across the ACP, the Pacific Loon is showing positive population trend, but the Red-throated Loon population is showing a significant declining trend (Larned et al. 2009).

Pacific Loon

Pacific Loons are common breeders across the entire coastal plain (Johnson and Herter 1989). They were the most abundant loons observed in the Project region and have been recorded as breeding in the area (WCC and ABR 1983; Rodrigues 2002a). Pacific Loons occur in the Project area from early May–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 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 the second-most abundant species on the barrier islands transects in the Project area (mean densities = 0.39 bird per square mile [0.15 bird per square kilometer] and 0.02 bird per square mile [0.01 bird per square kilometer], respectively) (LGL et al. 1999). In 1999, Noel et al. (2000a) found that Pacific Loons predominated in the lagoon system of the Project area during August–September surveys.

Limited information about habitat use by Pacific Loons in the Project 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). The single Pacific Loon nest found by Rodrigues (2002a) in 2002 was in aquatic graminoid tundra, a pond type with emergent *Arctophila fulva*. On the Colville River Delta, Pacific Loons nested on islands and shorelines in all types of waterbodies and also in terrestrial habitats bordering lakes, such as aquatic sedge, salt marsh, salt-killed tundra, non-patterned wet meadow, and wet sedge–willow meadow (Johnson et al. 1999a). 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; Kertell 1994) and nearshore marine waters (Andres 1993).

Red-Throated Loon

The Red-throated Loon is a common breeder on the ACP, including the Project region (Johnson and Herter 1989; Johnson et al. 1999a). Red-throated Loons were less abundant than Pacific Loons during all periods of the breeding season in the Project area (WCC and ABR 1983). Two Red-throated Loon nests were found in the Project 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, shallower ponds (often less than 3 acres [0.01 square kilometer]), than do the other species (Johnson and Herter 1989; 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; non-patterned wet meadow; and wet sedge–willow meadow (Burgess et al. 2000; Johnson et al. 2000a, 2000b). 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; Derksen et al. 1981).

In contrast to the other loons, which primarily feed in their nesting lakes, Red-throated Loons fly to nearshore marine waters to forage for 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 Project area during August–September (0.21 bird per square mile [0.08 bird per square kilometer] and 0.10 bird per square mile [0.04 bird per square kilometer], 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.

As noted above, Yellow-billed Loons are treated separately under Section 3.2.7, Threatened and Endangered Species.

3.2.4.5 Shorebirds

A total of 21 species of shorebirds have been recorded in the Project region, 13 of which are confirmed breeders in the area, on the basis of records of nests and/or broods (Table 3-24). Nine of these 13 breeding species (69 percent) currently are considered priority species for conservation by the ADF&G. Shorebirds are present in the Project region from May–September. They begin to arrive in late May, and most are present by early June. Littoral-zone habitats in the Project region are not used as migration staging areas by shorebirds during spring and early summer because shore-fast ice prohibits access to these areas at that time. In the spring and early summer on the ACP, shorebirds disperse quickly to establish breeding territories in snow-free tundra areas (Johnson and Herter 1989; Troy 2000). Nesting usually begins 7–10 days after arrival. The young hatch during late June–mid-July and are brooded by one or both adults for three to four weeks before fledging. During mid- to late summer, after the breeding season, many shorebirds move to the coast to feed in intertidal and saline-influenced habitats before beginning migration in August (Rothe et al. 1983; Andres 1989, 1994; Smith and Connors 1993).

Studies of shorebirds in the Project region are limited but include ground-based surveys for breeding shorebirds at Point Thomson in the early 1980s (WCC and ABR 1983) and studies in 2001–2002 by Rodrigues (2002a, 2002b). Studies conducted near the Project area include ground-based surveys for breeding shorebirds at the Yukon Gold ice pad about 6 miles (10 kilometers) south of Point Thomson (TERA 1993a, 1993b), and at the Badami development and Kadleroshilik River, about 19 and 30 miles (31 and 48 kilometers) west of Point Thomson, respectively (TERA 1994). A number of studies of shorebirds also have been conducted on the Canning River Delta in the Refuge, east of the Project area, including studies during 1979–1980 (Martin and Moitoret 1981), and annually from 2002–2006 (Kendall et al. 2003; Kendall and Brackney 2004; Kendall and Villa 2005, 2006; Kendall et al. 2007).

Across the ACP broadly, a 6-year study of shorebird occurrence (Johnson et al. 2007) indicates that the most common breeding shorebird species are Pectoral Sandpiper, Semipalmated Sandpiper, Long-billed Dowitcher, Red Phalarope, and Dunlin. In the Project area, WCC and ABR (1983) found that the most common nesting shorebirds were Baird's Sandpiper, Pectoral Sandpiper, Red Phalarope, and Long-billed Dowitcher (Table 3-24). Rodrigues (2002a, 2002b) found a somewhat different mix of common breeding species at Point Thomson, but Pectoral and Semipalmated Sandpipers were the two most abundant breeders in both 2001 and 2002. Other common species in the two years were Red-necked Phalarope and American Golden-Plover. Some of the apparent conflicts between these studies in the Project area in the determination of commonness of breeding shorebird species may reflect both differences in the habitats sampled and variability in nesting densities among years at a single site—large interannual variability in nesting densities of shorebirds is not unusual (TERA 1993a, 1993b; Troy 2000; Kendall et al. 2007).

The shorebird species recorded in the Project region are typical of other areas studied on the central ACP (between the Colville and Canning rivers; Troy 2000) although some species have not been recorded breeding at Point Thomson (likely they are migrants or visitants only) and others appear to occur there in lower numbers. A comparison of the nest-density data for shorebirds (Table 3-25), which covers study sites from Prudhoe Bay to the Canning River Delta, reveals that of the 14 species for which there are data, seven have lower nest densities at the Project site, two have higher densities, and five species have densities at the Project site that are higher compared to some sites and lower than others. Overall, when comparing nest densities of all shorebird species combined, the densities in the Project area appear roughly comparable to those found in the Sagavanirktok River Delta and slightly lower than at other coastal sites, such as the Badami development and the Kadleroshilik River areas. The nesting shorebird densities at the Project area are noticeably higher than those 6 miles (10 kilometers) inland at the site of the Yukon Gold ice pad, but lower than those at the coastal Point McIntyre area near Prudhoe Bay, and much lower than those in the Canning River Delta. Of the sites studied, the Canning River Delta in the Refuge has the highest densities of nesting shorebirds.

As a group, shorebirds in the Project region use a range of habitats for nesting, brood-rearing, and migration-staging. Consistent with other studies on the ACP, in the studies by WCC and ABR (1983) and Rodrigues (2002a, 2002b), plovers were found nesting on more well-drained upland habitats, while phalaropes and other sandpiper species nested in wetter tundra habitats, including wet sedge meadow, wet non-patterned tundra, and aquatic sedge and grass marsh. Rodrigues (2002a, 2002b) found that most shorebird nests were in 3 of 16 habitats in the Project area: moist sedge-dwarf shrub-wet graminoid tundra complex (41 percent [75 nests] and 29 percent [86 nests] of all nests in 2001 and 2002, respectively); wet sedge-moist sedge-dwarf shrub tundra complex (19 percent and 28 percent of nests); and moist sedge-dwarf shrub tundra (32 percent and 23 percent of nests). During brood-rearing, shorebirds move to wet tundra and aquatic habitats, often adjacent to the nest sites, where foraging is more productive. In the Project area, adult shorebirds with broods were seen using margins of lakes with and without emergent vegetation, wet strangmoor, and coastal marsh habitats (WCC and ABR 1983). These habitats, along with others used for nesting activities, support the primary food (insects and other small invertebrates) for shorebirds (Andres 1989; Johnson and Herter 1989). After the young fledge, many shorebirds form large feeding flocks, often of mixed species, and tend to congregate in coastal habitats (Smith and Connors 1993). Large movements of shorebirds to coastal habitats were not seen in the Project area in 1983, although use of coastal marshes has been observed (WCC and ABR 1983). The coastal shift in habitat use by shorebirds continued during the staging and fall migration periods in the Project area (WCC and ABR 1983).

3.2.4.6 Ptarmigan and Passerines

Rock Ptarmigan and Willow Ptarmigan are widespread on the ACP, particularly inland from the coast (Johnson and Herter 1989). Although both species have been observed in the Project region, to date only Rock Ptarmigan have been confirmed as breeding (Table 3-25). Most Rock Ptarmigan were seen in the moist non-patterned habitats in the area (WCC and ABR 1983). The single Rock Ptarmigan nest found in the Project area in 2001 was in moist sedge-dwarf shrub-wet graminoid tundra complex (Rodrigues 2002b). A few ptarmigan of either species may overwinter in the Project region, but most winter in the foothills of the Brooks Range (Johnson and Herter 1989).

Passerines (songbirds) occur on the ACP only during summer, with the exception of the two redpoll species: Common Redpoll and Hoary Redpoll. Most songbirds winter in temperate and tropical regions of the Americas or southern Asia. Of the eight species recorded in the Project region, only two (Lapland Longspur and Snow Bunting) are confirmed breeders (Table 3-24). The other species occur in the region during migration or as summer vagrants. The most abundant breeding passerine species in the Project region, as elsewhere on the ACP, is the

Lapland Longspur. Overall, nest densities of passerines in the Project region appear to be moderate or high relative to other sites on the ACP. For example, passerine densities in the Project region are roughly comparable to the densities in "high" years at the Canning River Delta, and comparable to the density in the Kadleroshilik River area. Passerine densities in the Project region are higher than at Point McIntyre (near Prudhoe Bay), the Sagavanirktok River Delta, and the Yukon Gold area, but lower than the density in the Badami Development area (Table 3-25).

Lapland Longspurs were found nesting in almost all habitat types in the Project region, but most nests were found in moist habitats (WCC and ABR 1983), wet sedge meadows, and dryas tundra (Wright and Fancy 1980). Rodrigues (2002a, 2002b) found most longspur nests in two habitats in the Project area: moist sedge-dwarf shrub tundra and moist sedge-dwarf shrub-wet graminoid tundra complex. In the Prudhoe Bay area, the highest densities of Lapland Longspur nests occurred in polygonized wet and moist meadows (Troy 1988).

3.2.4.7 Predatory Birds

Predatory birds recorded in the Project region include raptors (eight species, including owls), gulls (three species), jaegers (three species), and Arctic Tern and Common Raven (Table 3-24). On the North Slope, all these species are predators of birds (including eggs) and/or small mammals except for two species (Sabine's Gull and Arctic Tern), which prey largely on aquatic invertebrates and small fish. Except for the Common Raven, which is a year-round resident, all of these species winter farther south (Johnson and Herter 1989). Rodrigues (2002a, 2002b) conducted predator counts during the breeding-bird plot studies at the Project area in 2001–2002 and found the most common avian predators were Parasitic Jaeger, Glaucous Gull, and Common Raven, but also recorded were small numbers of other predatory species (Snowy Owl, Short-eared Owl, Long-tailed Jaeger, Pomarine Jaeger, Peregrine Falcon, Northern Harrier, Rough-legged Hawk, Golden Eagle, and Bald Eagle).

Raptors

None of the raptors (eagles, hawks, falcons, and owls) that occur on the ACP is a regular breeder in the Project 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). These owls probably nest in the Project area in years when small mammals are abundant. 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 are known to 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). A pair of Peregrine Falcons nested in an old raven nest on the radar tower at the Bullen Point SRRS in 2002 (Ritchie et al. 2003). Rough-legged Hawks also nested on man-made structures at the Bullen Point site in 2002 and 2006 (Ritchie et al. 2003; Frost et al. 2007).

Hence, even though the Project area is used by raptors, because of a general lack of suitable habitat, 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 (Federal Register [FR] 1994), and the species has now completed the 5-year monitoring period that followed 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 ESA, but still receives protection under the Migratory Bird Treaty Act (United States Code [USC] 1978), and is considered to be a bird species of conservation concern by the ADF&G (Table 3-26). Peregrines generally have been considered infrequent visitors to the coastal plain (Pitelka 1974; Johnson and Herter 1989) and regular breeders inland (Cade 1960; Pitelka 1974). Recent surveys in the NPR-A suggest, however, that individuals from the growing population of peregrines in the state 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; 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 Project 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 at the Bullen Point SRRS on a radar tower (Ritchie et al. 2003), on the lower Canning and Kavik rivers (Ambrose et al. 1988; Wildman and Ritchie 2000), and at Barter Island (Ritchie et al. 1998). Only a few Arctic Peregrine Falcon sightings have been reported during studies around the Project area: one near Point Sweeny in 1980 (Wright and Fancy 1980), one seen during late summer in 1983 (WCC and ABR 1983), and one during June 2002 (Rodrigues 2002a); this latter bird may have been from the pair observed nesting at the Bullen Point SRRS (Ritchie et al. 2003). A Peregrine Falcon also was observed at the Bullen Point SRRS in June 2003, but no evidence of nesting was found that year (Schick et al. 2004). Most use of the Project area by Arctic Peregrine Falcons occurs during occasional hunting forays during summer by adults, movements of young birds toward the coast after leaving nests farther inland, and passage of transient and migrating birds.

Other Predatory Species

Other predatory birds that occur in the Project region include gulls, jaegers, and the Arctic Tern (Table 3-24). Two species of gulls (Glaucous Gulls and Sabine's Gulls) breed in the Project region and these two species are common to uncommon breeders across the ACP, as well (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 in the Project area (Noel et al. 1999b).

All three species of jaegers occur in the Project area (Table 3-24), but only the Parasitic Jaeger is a regular breeder (Table 3-24). Pomarine Jaegers are common only during spring migration (early June) in the Project area (WCC and ABR 1983). Long-tailed Jaegers were found nesting in the Kadleroshilik area (Nickles et al. 1987; Field et al. 1988) and may nest occasionally elsewhere in the Project region. Little is known about nesting habitats for jaegers in the Project 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. 2000a, 2000b). In nest surveys conducted along the Canning River Delta, jeagers were found to be the most common predators observed, followed by the Glaucous Gull (Kendall et al. 2003; Kendall and Brackney 2004; Kendall and Villa 2005, 2006).

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

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, 2000a, 2000b). 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 widely throughout the Project area, given their broad habitat use and diverse prey.

Common Ravens are uncommon residents on the ACP, where they are closely associated with human habitations (Johnson and Herter 1989). Ravens occasionally nest near the coast, primarily on buildings and other structures, including oil field facilities (Johnson and Herter 1989; Ritchie 1991). Common Ravens occur in the Project area, and one apparently active nest was found at the Bullen Point SRRS site in 1994 (Day et al. 1995); no active raven nests were found in 2002–2003, 2006, or 2007 at the Bullen Point SRRS (Ritchie et al. 2003; Schick et al. 2004; Frost et al. 2007; Oasis Environmental Inc. 2009). Small numbers of ravens use the Project area during summer (WCC and ABR 1983; Rodrigues 2002a, 2002b). 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).

3.2.5 Marine Mammals

3.2.5.1 Project Area

The Project area for the seal, walrus, and whale assessment in the ER will include all waters immediately offshore of the Project to the barrier islands for all activities except ice roads. Most activities will be nearshore to the Project, which could include overflights of aircraft, barging, and on- and off-loading materials for the Project. The Project area would be extended beyond these boundaries for ice roads built on the sea ice, which could extend from Prudhoe Bay to Point Thomson. Ice roads built in less than 9.8 feet (3 meters) of water would be excluded from the analysis, because the National Marine Fisheries Service (NMFS) considers ice-covered waters less than 9.8 feet (3 meters) deep to be unoccupied by seals, the species of primary concern with the ice road construction and maintenance.

3.2.5.2 Whales, Seals, and Walruses

A total of nine marine mammal species (excluding polar bears, see Section 3.2.7, Threatened and Endangered Species) occur regularly or sporadically in the region of the Project area. These species include three baleen whales, two toothed whales, three true seals, and walruses. Of these, the bowhead whale is listed as endangered under the ESA (see Section 3.2.7, Threatened and Endangered Species). There are no species listed as threatened. In addition, the bowhead whale stock is considered depleted under the Marine Mammal Protection Act (MMPA); a species or population stock is considered depleted when it is below its optimum sustainable population size and/or is listed as threatened or endangered under the ESA. Recently, a humpback whale (with a calf), an endangered species, was reported for the first time in the Beaufort Sea about 54 miles (87 kilometers) east of Barrow (Hashagen et al. 2009). The species is not included in this ER, because the whale was beyond its normal range and it occurred at a considerable distance (about 100 miles or 160 kilometers) west of Prudhoe Bay and would not be expected to occur in the Project area.

The MMPA protects all marine mammals, whereas the ESA provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The MMPA is the regulatory mechanism normally used by the federal management agencies for oil and gas operations in Alaska. The MMPA also authorizes Alaska Natives living along the Arctic Ocean to harvest marine mammals for subsistence.

Table 3-29 provides an overview of the each species' status, habitat, prey, and listing under the ESA and MMPA. A brief description of each species is provided in the following section as a foundation for assessing potential project impacts. A section addressing subsistence harvest of marine mammals is also provided after the species accounts. Information in this report was obtained from Alaska Marine Mammal Stock Assessment Report; environmental reports; technical reports; scientific publications; and staff from the USFWS in Anchorage, National Marine Mammal Laboratory (NMML) in Seattle, and the NSB.

Non-Threatened or Endangered Species

Most bowheads and belugas migrate beyond the barrier islands, but on rare occasions one is reported within the barrier islands during late summer or fall. The other marine mammal species are not likely to be encountered, or if any are, the numbers would be very small because of their distribution patterns (offshore) or rare occurrences in the central Beaufort Sea.

TABLE 3-29: MARINE MAMMALS POTENTIALLY IN THE REGION OF THE PROJECT AREA AND THEIR FEDERAL/STATE STATUS

Species	Scientific Name	Relative Abundance	Primary Habitat	Primary Prey	Season(s) Present	ESA/MMPA Status
Gray Whale	*Eschrichtius robustus*	Uncommon	Coastal/ Shelf	Crustaceans	Summer-Fall	
Minke Whale	*Balaenoptera acutorostrata*	Uncommon	Shelf	Fish/Squid	Summer-Fall	
Bowhead Whale	*Balaena mysticetus*	Common	Shelf/ Offshore	Fish/ Zooplankton	Spring-Fall	Endangered/ Depleted
Beluga Whale	*Delphinapterus leucas*	Common	Shelf/ Offshore	Zooplankton	Spring-Fall	
Harbor porpoise	*Phocoena phocoena*	Uncommon	Shelf/ Coastal	Fish/ Squid	Summer-Fall	
Ringed Seal	*Pusa hispida*	Common	Shelf	Fish/ Zooplankton	Year-round	
Bearded Seal	*Erignathus barbatus*	Common	Shelf	Shellfish	Summer-Fall (some year-round)	
Spotted Seal	*Phoca largha*	Common	Shelf	Fish/ Zooplankton	Summer-Fall	
Pacific Walrus	*Odobenus rosmarus*	Uncommon	Shelf	Shellfish	Summer-Fall	

Notes:
ESA = Endangered Species Act
MMPA = Marine Mammals Protection Act

Baleen Whales

Gray Whales: There are two gray whale populations in the North Pacific Ocean, on the basis of geographic separation and an increase in the size of one population but not the other (Swartz et al. 2000). The small western North Pacific Ocean population, which summers near Sakhalin Island off Russia, is far from the Project area. The larger eastern North Pacific Ocean population summers in the Bering and Chukchi seas, and the western extreme of the Beaufort Sea, and largely winters in the lagoons off Mexico. The population is currently estimated at 18,813 whales, on the basis of the mean of the 2000–2001 and 2001–2002 estimates derived by Rugh et al. (2005). Based on the current population trend and estimates, (Rugh et al. 2005; Wade and Perryman 2002) stated that the population is near or at carrying capacity. The eastern North Pacific Ocean stock is not listed under ESA or considered by NMFS to be a depleted or a strategic stock.

Most summering gray whales congregate in the northern Bering Sea, particularly off St. Lawrence Island and in the Chirikov Basin (Moore et al. 2000), and in the southern Chukchi Sea. More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin has decreased, likely from the combined effects of changing currents resulting in altered secondary productivity dominated by lower-quality food. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea, southwest and west of Point Barrow (Clarke et al.

1989; Brueggeman et al. 1992). Gray whales were recently encountered relatively frequently in this region during vessel and aerial surveys conducted in conjunction with the 2006 to 2008 seismic programs operated by Shell and CGGVeritas (Ireland et al. 2009). Similar findings were reported during a 2008 ConocoPhillips and Shell research program (Brueggeman et al. 2009a, 2009b). Recently, acoustic studies suggest some gray whales may winter in the western Alaska Beaufort Sea north and northeast of Point Barrow (Moore et al. 2006). The increased frequency of gray whale sightings in this region is likely a reflection of recovery of the population to pre-exploitation levels and the need to expand their range.

Only a small number of gray whales enter the Beaufort Sea east of Point Barrow from the Chukchi Sea. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). Only one gray whale was sighted in the central Alaska Beaufort Sea during the extensive aerial survey programs funded by MMS and the oil and gas industry from 1979 to 1997. However, during September 1998, small numbers of gray whales were sighted on several occasions in the central Alaska Beaufort Sea (Miller et al. 1999; Treacy 2000). More recently, a single sighting of a gray whale was made on 1 August 2001 near the Northstar production island (Williams and Coltrane 2002). Several single gray whales have been seen farther east in the Beaufort Sea (Rugh and Fraker 1981; LGL Ltd. unpublished data), indicating that a few must travel through the region during some summers. In recent years, ice conditions were less dense near Barrow, and gray whales may have become more common (Goetz et al. 2009). In the springs of 2003 and 2004, a few tens of gray whales were seen near Barrow by early–mid-June (LGL Ltd. and NSB Department of Wildlife Management unpublished data). Ireland et al. (2009) reported 1–13 gray whale sightings during vessel surveys between 2006–2008 across the Beaufort Sea.

Minke Whales: Very little is known about minke whale use of the Beaufort Sea except numbers are very small. Recent surveys by Ireland et al. (2009) encountered one minke in 2006 and 2007 and two in 2008 during extensive aerial and vessel surveys. None were seen during the 2008 or 2009 Bowhead Whale Feeding Study surveys (Goetz et al. 2009) conducted north and northeast of Point Barrow. Minke whales typically occur as solitary animals found beyond the barrier islands over the shelf and shelf break in the Beaufort Sea. There are no estimates for minke whales in the Chukchi or Beaufort seas, but numbers are assumed to be very low because this area is the northern extreme of its range.

Toothed Whales

Beluga Whales: In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). Only the Beaufort Sea stock and eastern Chukchi Sea stock seasonally occur in the Beaufort Sea. Beluga whales are an important subsistence resource for residents of the villages along the Chukchi and Beaufort seas. The Beaufort Sea population is estimated to be in excess of 39,258 whales (Angliss and Outlaw 2008). An estimated 2,500–3,000 beluga whales summer in the northwestern Beaufort Sea (USDI MMS 2003). This eastern Chukchi Sea stock was estimated at a minimum of about 3,710 whales (Angliss and Outlaw 2008). These two populations are not considered by NMFS to be depleted or strategic stocks, and they were believed to be stable or increasing at the time of the most recent stock assessments (DeMaster 1995).

The Beaufort Sea stock of beluga whales winters in the Bering Sea, summers in the eastern Beaufort Sea, and migrates around western and northern Alaska (Angliss and Outlaw 2008). Most of these belugas migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984). Much of this stock enters the Mackenzie River estuary during July–August to molt, but they spend most of the summer in offshore waters of the eastern Beaufort Sea and Amundsen Gulf (Davis and Evans 1982; Harwood et al. 1996; Richard et al. 2001). Belugas are rarely seen in the central Alaska Beaufort Sea during summer. During late summer and autumn, most belugas migrate far offshore near the pack ice front (Frost et al. 1988; Hazard 1988). However, during the westward migration in late summer and autumn, small numbers of belugas are sometimes seen near the north coast of Alaska (Johnson 1979). Nonetheless, the main fall migration corridor of beluga whales is approximately 62.1 miles (100+ kilometers) north of the coast. Satellite-linked telemetry data show that some belugas migrate west considerably farther offshore, as far north as 76ºN to 78ºN latitude (Richard et al. 1997, 2001).

The eastern Chukchi Sea stock seasonally inhabits the coastal areas off Alaska. Belugas have been predictably sighted near the Kasegaluk Lagoon from late June–mid- to late July before moving north and northeast into the summering ground (Suydam et al. 2001). Suydam et al. (2001, 2005) satellite-tagged 16 belugas in Kasegaluk Lagoon between 1998 and 2006, and found they moved north to and beyond the outer edge of the continental shelf in both the Chukchi and Beaufort seas, with some going deep (80ºN latitude) into the heavy pack ice (90 percent cover) and others going into Canadian waters before returning to the Chukchi Sea in the fall and eventually back to the Bering Sea wintering grounds (Lowry et al. 1999 in Lowry 2001; Suydam et al. 2001, 2005). None of the tagged whales summered on or migrated across the OCS in the Beaufort Sea, thereby placing them considerably beyond the areas used by the oil and gas industry, including the Project area. However, isolated beluga whales could be encountered in the Project area, primarily during fall migration. These data suggest the stock ranges over a broad area, including considerably north of the Alaska coast, into heavy ice cover over very deep waters.

Harbor Porpoises: Harbor porpoises in Alaska waters primarily occur in the Bering Sea and southward (Angliss and Outlaw 2008). Small numbers of harbor porpoises summer in the Chukchi Sea and a few inhabit the Beaufort Sea. Harbor porpoises primarily occur as singles or pairs nearshore in bays and lagoons but have been reported considerably offshore in the Chukchi Sea (Brueggeman et al. 2009a, 2009b; Ireland et al. 2009) and the Beaufort Sea (Ireland et al. 2009). Their rarity in the Beaufort Sea is evidenced by the results of aerial and vessel surveys conducted in 2006, 2007, and 2008, where only one harbor porpoise was observed between the villages of Barrow and Kaktovic (Ireland et al. 2009).

Seals and Walruses

Ringed Seals: The most likely marine mammals (excluding polar bears) encountered in the vicinity of the Project area would be seals, primarily ringed seals. The numbers would be small relative to the size of the populations. Ringed seals could be encountered year-round, including during winter/early spring when they occupy lairs on the sea ice.

Ringed seals have a circumpolar distribution, which is closely associated with sea ice. Ringed seals are found throughout the Bering, Chukchi, and Beaufort seas (Angliss and Outlaw 2008). They are the most abundant and widely distributed seal in the Chukchi and Beaufort seas (King 1983; Ireland et al. 2009).

Although there are no recent population estimates for the Alaska Arctic, Bengtson et al. (2005) estimated ringed seal abundance from Barrow south to Shishmaref in the Chukchi Sea to be 252,488 (Standard Error [SE]=47,204) for 1999 and 208,857 (SE=25,502) in 2000 for an average of 230,673 seals. Frost et al. (2002) estimated a density of 0.38 seal per square mile (0.98 per square kilometer) for 6,949.8 square miles (18,000 square kilometers) surveyed in the Beaufort Sea, which Angliss and Outlaw (2008) combined with the average estimate from Bengtson et al. (2005) for a total minimum estimate of 249,000 ringed seals in the Beaufort and Chukchi seas. This is a minimum estimate, because Frost et al. (2002) and Bengtson et al. (2005), surveyed a small part of the ringed seal habitat in the Beaufort and Chukchi seas, and Frost et al. (2002) did not correct for missed seals. Consequently, estimates are likely much higher than reported, and they could be as high or approach past estimates of 1 million–3.6 million ringed seals in the Alaska stock (Frost 1985; Frost and Lowry 1988; Frost et al. 1988).

Results from surveys by Bengtson et al. (2005) in May and June of 1999 and 2000 indicated ringed seal densities are higher in nearshore fast ice and pack ice, and lower in offshore pack ice, which is less stable and extensive. However, in some areas where there is limited fast ice but wide expanses of pack ice, the total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970; Stirling et al. 1982; Finley et al. 1983). Frost et al. (2004) reported slightly higher ringed seal densities in the pack ice (0.36–0.51 seal per square mile or 0.92–1.33 seals per square kilometer) than in the shorefast ice (0.22–0.44 seal per square mile or 0.57–1.14 seals per square kilometer) in the central Beaufort Sea during late May and early June of 1996–1999, when seals are most commonly hauled out on the ice. Wiig et al. (1991) found highest seal densities on stable landfast ice, but significant numbers of ringed seals also occur in pack ice. During summer, high densities of ringed seals are associated with ice remnants (MMS 2003). Ireland et al. (2008) reported widespread ringed seal occurrence in open water during summer and fall between Barrow and Kaktovik but did not indicate any area of high geographic preference. These results suggest that ringed seal use of the Beaufort Sea is widespread in the sea ice but somewhat higher in nearshore than offshore ice during spring, after which they occur in areas of ice remnants and open water during summer. Sea ice use depends on a variety of seasonal, environmental, and seal behavioral conditions, but appears to be relatively similar between the Chukchi and Beaufort seas.

Ringed seals are a polygamous species. When sexually mature, they establish territories during the fall and maintain them during the pupping season. Pups are born in late March and April in lairs that seals excavate in snowdrifts and pressure ridges in waters deeper than 9.8 feet (3 meters) where there is sufficient open water under the ice. During the breeding and pupping season, adults on shorefast ice (floating fast-ice zone) usually move less than individuals in other habitats; they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. During nursing (four to six weeks), pups usually stay in the birth lair. Alternate snow lairs provide physical and thermal protection when the pups are being pursued by their primary predators, polar bears and Arctic foxes (MMS 2003).

The primary prey of ringed seals is Arctic cod, saffron cod, shrimps, amphipods, and euphausiids (Kelly 1988; MMS 2003). Ringed seals are an important resource that subsistence hunters harvest in Alaska (MMS 2003).

Bearded Seals: Bearded seals, the second most common seal in the Arctic, are associated with sea ice and have a circumpolar distribution (Burns 1981). During the open water period, bearded seals occur mainly on the outer continental shelf, because they are predominantly benthic feeders (Burns 1981). They prefer areas no deeper than 656.2 feet (200 meters) (Harwood et al. 2005).

Bearded seals occur over the continental shelves of the Bering, Chukchi, and to a lesser extent the Beaufort seas (Burns 1981). Reliable estimates of bearded seal abundance in Alaska waters are unavailable (Angliss and Outlaw 2008). However, Bengtson et al. (2005) estimated the average density for the eastern Chukchi Sea to be 0.03–0.05 seal per square mile (0.07–0.14 seal per square kilometer) between Barrow and Shishmaref from surveys conducted in 1999 and 2000. While Bengston did not adjust the density for haulout behavior to estimate abundance, he did state that actual densities could be of a magnitude 12.5 times higher or 0.34–0.68 seal per square mile (0.87–1.75 seals per square kilometer). Extrapolating these densities to abundance would put the number below but close to the estimate of ringed seals (230,000) in the Chukchi Sea. Whereas there are no current estimates for bearded seal in the rest of their range off Alaska, early estimates of the entire Alaska stock ranged from 250,000–300,000 seals (Angliss and Outlaw 2008; Popov 1976; Burns 1981), which may be reasonable if not low given the estimate suggested by Bengtson et al. (2005) for a small part of their range. The Alaska stock of bearded seals is not classified by NMFS as depleted or a strategic stock.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter, most bearded seals are in the Bering Sea. In the Chukchi and Beaufort seas, favorable conditions are more limited, and consequently, bearded seals are scarce there during winter. From mid-April to June, as the ice recedes, some of the bearded seals over-wintering in the Bering Sea migrate northward through the Bering Strait. During summer, they occur near the widely fragmented margin of multi-year ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea.

In some areas, bearded seals are associated with the ice year-round; however, they usually move shoreward into open water areas when the pack ice retreats to areas with water depths greater than 656.2 feet (200 meters). During summer, when the Bering Sea is ice-free, the most favorable bearded seal habitat is found in the central or northern Chukchi Sea along the margin of the pack ice. Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack ice edge frequently occurs seaward of the shelf and over water too deep for benthic feeding.

Pupping takes place on top of the ice less than 3.2 feet (1 meter) from open water from late March–May, mainly in the Bering and Chukchi seas, although some takes place in the Beaufort

Sea (MMS 2003). These seals do not form herds, but sometimes do form loose groups. Bearded seals feed on a variety of benthic prey, decapod crustaceans (crabs and shrimp) and mollusks (clams), and other food organisms, including Arctic and saffron cod, flounders, sculpins, and octopuses (Kelly 1988; MMS 2003). Bearded seals are an important and culturally preferred species for meat and oil, and their processed skins are used for covering traditional skin whaling boats.

Spotted Seals: Spotted seals (also known as largha seals) seasonally occur in the Beaufort, Chukchi, and Bering seas (Shaughnessy and Fay 1977). Spotted seals occur in large numbers along the Chukchi Sea coast from June–October (MMS 1990a) and in lower numbers along the Beaufort Sea coast, hauling out on beaches, barrier islands, and remote sandbars on the river deltas (MMS 2003). Haulouts within Kasegaluk Lagoon in the Chukchi Sea contain among the largest spotted seal concentrations in Alaska (Frost et al. 1993). Spotted seals migrate from the Chukchi or Beaufort seas in the fall to the Bering Sea, where they winter.

A reliable estimate of spotted seals is currently not available. However, surveys conducted by Rugh et al. (1993) in the Bering Sea and at known haulout sites resulted in maximum counts of 4,145 in 1992 and 2,591 in 1993. Using the maximum count with a correction factor for missed seals, Angliss and Outlaw (2008) developed an estimate of 59,214 spotted seals. This represents a minimum estimate, since a substantial portion of their range was not included in the survey.

During spring, when pupping, breeding, and molting occur, spotted seals are along the southern edge of the sea ice in the Bering Sea (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Subadults may be seen in larger groups of up to 200 animals. During summer, spotted seals are primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July–September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. The seals are commonly seen in bays, lagoons, and estuaries, but also range offshore as far north as 69–72ºN. In summer, they are rarely seen on the pack ice, except when the ice is very near to shore. Spotted seals leave the Chukchi and Beaufort seas as ice cover thickens with the onset of winter and move into the Bering Sea (Lowry et al. 1998). Important prey includes pelagic fishes, octopuses, and crustaceans.

Pacific Walruses: There are no current estimates of the size of the Pacific walrus population. The actual size of the pre-exploitation population has been estimated between 200,000–250,000 animals. Cooperative aerial surveys by the United States and the former Soviet Union (now Russia) were conducted between 1975 and 1990 (Gilbert et al. 1992; Seagars 1992). The 1975 survey estimated the population size at 221,360; the 1980 at 246,360; the 1985 at 234,020; and the 1990 at 201,039 animals. However, a considerable portion of the eastern Chukchi Sea usually inhabited by walruses in more typical ice years was not surveyed in 1990 because ice was not present. These collective estimates suggest the population was within the range of its pre-exploitation size between 1975 and 1990. Whereas there is no more recent population estimate than the 1990 estimate of 201,039, there is no evidence to suggest the population has significantly changed in size over the last 15 years. This is partially supported by the most recently available Alaska Native harvest records, which show relatively similar harvest levels (mean = 2,257) each year from 1996–2000 (Angliss and Lodge 2004).

The Pacific walrus mainly inhabits the shallow continental shelf waters of the Bering and Chukchi seas, with very small numbers entering the Beaufort Sea. The distribution of Pacific walruses varies markedly with the seasons. Virtually the entire population occupies the pack ice in the Bering Sea in winter (Fay 1982). As the Bering Sea pack ice begins to loosen in April, walruses begin to move northward. By late April, the distribution extends from Bristol Bay northward to the Bering Strait, and by May into the southern Chukchi Sea. During summer, as the pack ice continues to recede northward, nearly all of the adult females, calves, and subadults migrate into the Chukchi Sea and a few into the Beaufort Sea, while most adult males remain in the Bering Sea. Broadscale surveys conducted by Ireland et al. (2009) in the Beaufort Sea from 2006–2008 reported 0–11 walruses, including five or fewer single walruses, offshore of Camden Bay and Prudhoe Bay, considerably beyond the barrier islands.

Mating usually occurs between January and March, and calves are born 15 months later between April and June during the annual northward migration (Fay 1982).

Walruses mainly feed on bivalve mollusks obtained from bottom sediments along the shallow continental shelf, typically at depths of 262 feet (80 meters) or less (Fay 1982). Walruses feed on a variety of benthic invertebrates, such as: worms, snails, shrimp, and some slow-moving fish (Jefferson et al. 1993). They mainly feed between June and November when the young are growing and adult females are accumulating fat stores for the breeding season (Fay 1982).

Subsistence

Marine mammals are of key importance in the subsistence economies of the communities bordering the Beaufort Sea, which include Kaktovik, Nuiqsut, and Barrow. The whale harvests have a great influence on social relations by strengthening the sense of Inupiat culture and heritage, in addition to reinforcing family and community ties. All of the villages and offshore hunting areas are a considerable distance from the Project. Subsistence is essentially the only human-caused mortality to marine mammals in Arctic waters off the Alaska coast, because other typical sources such as commercial fishing do not occur, and vessel strikes are unlikely because of the low traffic, small size, and narrow travel range of vessels. There have been no documented injuries or deaths of seals, walruses, or whales by oil and gas operations in the Chukchi or Beaufort seas.

Bowhead whales are important for subsistence in all of the villages along the Beaufort Sea coast. The harvest is based on a quota, established by the International Whaling Commission (IWC) and regulated by agreement between the Alaska Eskimo Whaling Commission (AEWC) and NMFS, according to the cultural and nutritional needs of Alaska Natives, as well as on the basis of estimates of the size and growth of the stock of bowhead whales (Suydam and George 2004). In 2007, the IWC set a 5-year block quota (2008–2012) of 67 strikes per year with a total landed not to exceed 255 whales (Angliss and Outlaw 2008). The total number of whales landed in 2006 (most recent data) was 31, which is lower than the average number landed over the previous 10 years (1996–2005: mean=41.8 whales, SD=6.8; Suydam et al. 2007; no estimate is available for 2008). The lower harvest was attributable to difficult sea ice conditions during the spring harvest for some villages.

Villagers hunt bowheads during the spring and/or fall migrations. Nuiqsut and Kaktovik hunt only during the fall migration (Suydam et al. 2005; Suydam and George 2004). The village of Barrow hunts during the spring and fall migrations, typically taking most bowheads during the spring migration; Barrow hunters consistently harvest far more bowheads than any other village. The spring bowhead hunt occurs after leads open because of the deterioration of pack ice, which typically occurs from early April until the first week of June.

The fall hunt by Barrow, Nuiqsut, and Kaktovik whalers occurs in open water from late August–October. The autumn hunt at Kaktovik occurs in late August to mid-September, at Nuiqsut from early September–October, and at Barrow from mid-September to October. Nuiqsut and Kaktovik are the closest villages to the Project area. Kaktovik whalers hunt mainly in the waters off the village, which is almost 62.1 miles (100 kilometers) east of the Project area. Nuiqsut whalers hunt from Cross Island, which is almost 52.8 miles (85 kilometers) west of the Project area. The whales have usually moved out of the Beaufort Sea by late October to mid-November (Treacy 2002a, 2002b). The location of the fall hunt depends on ice conditions, which can influence distance of whales from shore (Brower 1996). Hunters prefer to take bowheads close to shore to avoid a long tow, during which the meat can spoil.

Beluga whales are hunted for subsistence at Kaktovik and Barrow in the Beaufort Sea (Fuller and George 1997). Alaska Natives averaged 53 beluga whales from 1999–2003, according to the most recently available harvest information (Angliss and Outlaw 2008). No information is available about harvests by villages along the Beaufort Sea.

Ringed, bearded, and spotted seals are hunted by Alaska Natives living in the villages bordering the Beaufort Sea (Fuller and George 1997). There are no current annual estimates of the numbers of seals harvested by subsistence hunters. Data collected by ADF&G before 2000 documented subsistence harvest of ringed, bearded, and spotted seals numbering 9,567, 6,788, and 5,265, respectively (Angliss and Outlaw 2008). Ringed seals comprise the largest part of the subsistence hunt and spotted seal the least.

Walruses are occasionally harvested by hunters from Barrow, but are not taken by the other villages because of the low numbers in the Beaufort Sea. There are no data available about the number of walruses harvested in the Beaufort Sea.

3.2.6 Terrestrial Animals

Eighteen species of terrestrial mammals have been documented or are likely to occur in suitable habitats in the Project area (Table 3-30). None of these species are federally-listed as threatened and endangered species. The area of interest is at the limit of the ranges of another eight species of terrestrial mammals that only may occur there rarely, if at all. Investigations of terrestrial mammals in the Project area have focused almost entirely on large mammals, consisting mostly of aerial surveys documenting the distribution and movements of caribou. Sightings of muskoxen, moose, and grizzly bears also were recorded during those surveys (described separately under each species, below), and tracking of radio-collared animals (telemetry) provided additional data for caribou, muskoxen, and grizzly bears. In contrast to the large amount of effort expended on large mammals, very little research about small mammals or furbearers has been conducted in the Project area, except for several fox den surveys.

The earliest large-mammal surveys that focused on portions of the Project area were aerial surveys in the 1970s and early 1980s, some involving radio telemetry (Quimby and Snarski 1974; WCC and ABR 1983; Whitten and Cameron 1985; Lawhead 1988). ADF&G and USFWS have conducted telemetry surveys of collared caribou since the early 1980s (Cameron et al. 1995, 2002; Griffith et al. 2002; Lenart 2009a). Aerial-transect surveys of caribou and other large mammals were conducted specifically in the Project area (referred to as the Bullen–Staines study area) during 1994–2003 (Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 2001; Noel and King 2000b; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003) and in the adjacent Badami Development area, which included the western portion of the proposed Point Thomson export pipeline route (Pollard 1994; Pollard and Noel 1995; Noel 1998; Noel and Olson 1999e, 2001; Noel and King 2000b; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003). ADF&G flew transect surveys in the area during the caribou calving season periodically from the late 1970s to the early 1990s (Whitten and Cameron 1985; Lenart 2001; Lenart 2007a, 2007b, 2007c). USFWS and ADF&G have radio-tracked collared muskoxen on the eastern and central portions of the ACP since the early 1980s (Reynolds et al. 2002a, 2002b; Reynolds 2006; Lenart 2009b). Some grizzly bear observations were recorded in the area in 1972 (Quimby and Snarski 1974), during baseline surveys for the Arctic Gas Pipeline project that was proposed in the early 1970s. ADF&G flew a transect survey for grizzly bears in the Project area in 1997, conducted habitat assessments in 1998 and 1999, and has radio-tracked collared bears in the general area since 1998 (Shideler 1999, 2000, unpublished data). Surveys of Arctic fox dens were conducted in various portions of the Project study area in 1972 (Quimby and Snarski 1974), 1983 (WCC 1983), 1992 (Burgess et al. 1993), and 1999–2000 (Perham 2000, 2001); additional observations of den prospects were recorded during the aerial-transect surveys for large mammals, listed above.

TABLE 3-30: TERRESTRIAL MAMMAL SPECIES OCCURRING IN THE POINT THOMSON REGION

English Name	Scientific Name	Iñupiaq Name	Status
Arctic ground squirrel	*Spermophilus parryii*	Siksrik, Sigrik	√
Collared lemming	*Dicrostonyx groenlandicus*	Qixanmiutaq	√
Brown lemming	*Lemmus trimucronatus*	Aviffapiaq	√
Singing vole	*Microtus miurus*	Aviffaq	√
Root vole (tundra vole)	*Microtus oeconomus*	Aviffaq	√
Northern red-backed vole [1]	*Myodes rutilus*	Aviffaq	*
North American porcupine [1]	*Erethizon dorsatum*	Qifabluk	*
Snowshoe hare [a]	*Lepus americanus*	Ukalliatchiaq	*
Alaska hare (tundra hare) [2]	*Lepus othus*	Ukallisugruk	*
Tundra shrew	*Sorex tundrensis*	Ugrugnaq	√
Barren ground shrew	*Sorex ugyunak*	Ugrugnaq	√
Alaska tiny shrew	*Sorex yukonicus*	Ugrugnaq	√
Canadian lynx [1]	*Lynx canadensis*	Niutuiyiq	*
Coyote [1]	*Canis latrans*	Amabuuraq	*
Wolf	*Canis lupus*	Amabuq	√
Arctic fox	*Vulpes lagopus*	Tibiganniaq	√
Red fox	*Vulpes vulpes*	Kayuqtuq	√
Brown bear (grizzly bear)	*Ursus arctos*	Akjaq	√
Wolverine	*Gulo gulo*	Qavvik	√
North American river otter [1]	*Lontra canadensis*	Pamiuqtuuq	*
Ermine (short-tailed weasel)	*Mustela erminea*	Itibiaq	√
Least weasel	*Mustela nivalis*	Naulayuq	√
American mink [1]	*Neovison vison*	Itibiaqpak	*
Moose	*Alces americanus*	Tuttuvak	√
Caribou	*Rangifer tarandus*	Tuttu	√
Muskox	*Ovibos moschatus*	Umifmak	√

Notes:
Source: English and scientific names follow MacDonald and Cook (2009); alternative English names are in parentheses. Iñupiaq names follow MacLean (1980), with spelling updated by L. Kaplan (University of Alaska Fairbanks Alaska Native Language Center, personal communication 1996).
[1] Although these species may occur in some areas of the Arctic Coastal Plain, they are unlikely to occur in the Point Thomson region because of its distance from major riparian corridors or other habitat characteristics.
[2] Formerly documented on North Slope (Bee and Hall 1956), but probably no longer occurs there (MacDonald and Cook 2009).
√ = species documented or very likely to occur in the region.
* = species that, if present, is rare in the study area and at the limits of its range.

3.2.6.1 Caribou

Caribou are a vitally important component of the Arctic landscape in Alaska because of their high value to subsistence and sport hunters, indigenous Alaska Native cultures, the general public, and the functioning of terrestrial ecosystems. Caribou are the most ecologically significant mammalian herbivores in the Project area. For many people, the well-being of caribou populations is regarded as an indicator of the health of Arctic ecosystems. Thus, maintaining viable, healthy herds is a high-priority management issue and caribou figure prominently in land-use decisions in Arctic Alaska.

Herd Distribution and Abundance

Caribou are managed by ADF&G, which follows Skoog (1968) in identifying herds based on their fidelity to calving grounds. On the basis of this criterion, four herds are recognized in Arctic Alaska (proceeding from west to east): the Western Arctic Herd (WAH), the Teshekpuk Herd (TH), the Central Arctic Herd (CAH), and the Porcupine Herd (PH). The Project area is used predominantly by CAH caribou and to a lesser extent by PH caribou, although about a third of the TH traveled east and overwintered in the Refuge during an unusual movement in 2003–2004 (Carroll 2007; Person et al. 2007); during that event, many of TH animals traveled through the Project area.

The CAH is the principal herd using the Project area. The CAH ranges from the northeastern NPR-A and Colville River drainage on the west to the Refuge on the east (Figure 3-17). Telemetry studies have shown that, in most years, roughly half of the CAH (called the eastern segment) tends to calve east of the Sagavanirktok River (including the vicinity of the Project), while the other half (western segment) calves west of the Sagavanirktok River, including the area occupied by the Prudhoe Bay and Kuparuk oil fields and associated satellite developments (Lawhead 1988; Cameron et al. 1995; Arthur and Del Vecchio 2007). The two calving segments of the CAH are not isolated from each other. Interchange between segments, primarily among years but also within years, has been estimated roughly at 20–25 percent (Lawhead and Curatolo 1984; Lenart 2001; Arthur 2001). The two herd segments formerly tended to remain on their respective sides of the Sagavanirktok River during the insect season (Murphy and Lawhead 2000), but that separation has broken down in the last five years or so and the entire herd mixes during seasons other than calving (Arthur and Del Vecchio 2007; Lenart 2009a). The level of mixing of these two herd needs further quantification.

The CAH increased steadily from a few thousand animals (approximately 3,000 animals in 1972 and 4,000–6,000 animals in the mid-1970s), when it was first recognized by ADF&G as a distinct herd (Cameron and Whitten 1979), to a peak of approximately 23,400 in July 1992 (Lenart 2009a) before subsequently declining. Between 1992 and 1995, the CAH declined 23 percent, to approximately 18,100 caribou (Lenart 2009a). Since then, the herd has increased steadily, reaching approximately 19,700 caribou by July 1997, approximately 27,100 caribou by July 2000, approximately 31,900 caribou by July 2002, and approximately 66,800 in July 2008, the largest size recorded thus far for the herd (Figure 3-18; Lenart 2009a).

During summer, caribou in the western half of the CAH range regularly encounter oil field infrastructure (drill-site pads, roads, pipelines, processing facilities) and industrial activities in the Prudhoe Bay and Kuparuk oil fields and associated satellite fields. Since the Badami Development project was completed in 1998, it is likely most of the caribou in the eastern half of the CAH range encounter that pipeline corridor each summer. All members of the herd probably encounter the Trans Alaska Pipeline multiple times during their lifetimes.

In contrast to the CAH, the PH has little contact with human industrial activity. PH caribou have no exposure to industrial activity on their summer range, although many cross the Dempster Highway (completed in 1978) in the Yukon during spring and fall migrations.

The PH is an international resource whose range extends from the vicinity of the Project area and the western boundary of the Refuge in northeastern Alaska to the central Yukon and western fringe of the Northwest Territories in Canada (Figure 3-17; Griffith et al. 2002). This herd typically calves on the coastal plain and northern foothills of the Brooks Range, within the Refuge, and in the Yukon (Figure 3-17), and has been the focus of a substantial amount of research in the last three decades (Russell et al. 1993; Garner and Reynolds 1986; Griffith et al. 2002; Lenart 2007).

After increasing about 5 percent annually during 1976–1989, the PH decreased 10 percent from 178,000 in 1989 to 160,000 in 1992 (Whitten 1995). The 1994 estimate of 152,000 may have been an underestimate, and the herd was thought to have stabilized at approximately 160,000 animals after 1992 (K. Whitten, personal communication). However, the decline of the herd continued to approximately 129,000 by 1998 (Stephenson 1999) and approximately 123,000 by 2000, the year of the most recent photocensus (Griffith et al. 2002) (Figure 3-18). Despite several attempts, a photocensus has not been completed since 2000 and the current size of this herd is unknown. On the basis of population modeling, survivorship analysis, and herd-composition surveys, the PH is thought to have continued to decline to approximately 110,000–115,000 caribou by 2006 (Lenart 2007). The decline of the PH cannot be accounted for on the basis of calf production and survival, and reduced adult survival is implicated in the herd decline (Griffith et al. 2002; Arthur et al. 2003).

The annual life cycle of Arctic caribou has been subdivided into different seasonal phases for descriptive purposes by various authors (Roby 1978; Russell et al. 1993). The greatest use of the Project area by caribou occurs in spring and summer, from the calving period (late May to mid-June) through the insect-harassment season (late June to mid-August).

Seasonal Range Use

Calving Season

Most CAH caribou occur on the outer (northern) portion of the coastal plain during the calving and insect seasons (Cameron et al. 1995; Murphy and Lawhead 2000; Arthur and Del Vecchio 2007). By May, pregnant cows move north and disperse widely over the coastal plain to calve in late May to early June; each cow bears one calf. Peak calving usually occurs in the first week of June (Arthur and Del Vecchio 2007; Lenart 2009a). In most years, calving by the CAH is concentrated in two general areas (Figure 3-17): west of the Sagavanirktok River, in the vicinity of the Kuparuk oil field, and east of the Sagavanirktok River, generally south of Bullen Point and sometimes extending eastward to the Staines River (Whitten and Cameron 1985; Murphy and Lawhead 2000; Cameron et al. 2002; Arthur and Del Vecchio 2007; Lenart 2009a).

A substantial amount of effort has been invested in aerial surveys of caribou distribution and abundance in the eastern calving concentration area, between Bullen Point and the Staines River, which was used heavily by the CAH from the late 1970s to the mid-1980s (Whitten and Cameron 1985; Wolfe 2000), and which includes the Project area. Besides partial coverage annually by ADF&G from the late 1970s to the early 1990s, calving surveys were done in the Project area in 1983 (WCC and ABR 1983; Lawhead and Curatolo 1984), 1984 (Curatolo and Reges 1985), 1987–1990 (Lawhead and Cameron 1988; Smith and Cameron 1992) and 1993, 1995, and 1997–2003 (Pollard and Noel 1995; Noel 1998a; Noel and Olson 1999a, 2001a; Noel and King 2000a; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003). Wolfe (2000) conducted a retrospective Geographic Information System (GIS) analysis of calving area/habitat selection, using ADF&G radio-telemetry data from 1980–1995. Arthur and Del Vecchio (2007) conducted a telemetry study comparing growth and survival of CAH calves born in the eastern and western calving areas.

Calving surveys since the late 1970s show that the Bullen–Staines concentration area was used most heavily for calving before the mid-1980s, in terms of the proportion of the CAH using the area (Figure 3-19; WCC and ABR 1983; Wolfe 2000). The area of most concentrated calving activity (as assessed by radio-collared females) encompassed the Project 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 (Wolfe 2000). The area of most concentrated calving fluctuated during 2001–2005, occurring in the Bullen–Staines area only during 2002 (Arthur and Del Vecchio 2007). After 2003, the area of most concentrated calving has been located west of the Bullen-Staines area, in the area between the Kadleroshilik and Shaviovik rivers (Arthur and Del Vecchio 2007; E. Lenart unpublished data). Transect surveys in the 1990s (Figure 3-20; Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 1999e, 2001; Noel and King 2000b; Jensen and Noel 2002; Noel and Cunningham 2003), and radio-telemetry information collected by ADF&G since 2002, corroborate the shift of the most concentrated calving activity to the southwest of the Project facilities. For the period 1990–2002, the Project area was in the 75–95 percent range of utilization distributions (Figure 3-19), but the relative use of the Project area for calving has decreased substantially since 2004 (Arthur and Del Vecchio 2007; E. Lenart unpublished data).

Calving surveys for PH caribou have been conducted annually since the mid-1970s, including telemetry studies since the early 1980s (Griffith et al. 2002). The location and level of annual use of the PH calving grounds have been described and mapped in detail (Figure 3-17; Griffith et al. 2002; Jones 2005). Calving data analyses, based on telemetry of PH females using very-high frequency (VHF) and satellite collars, have been summarized by USFWS and Canadian researchers in a series of publications (Garner and Reynolds 1986; Russell et al. 1993; Griffith et al. 2002; Jones 2005). Extensive telemetry data collected annually during 1983–2001 demonstrated that little calving activity by the PH occurs in the western portion of the Refuge coastal plain, and that no PH calving or calf movements were detected west of the Canning

River in the Project area (Russell et al. 1993; Griffith et al. 2002; Jones 2005). The lack of PH caribou locations in this season confirms that the caribou calving in the Project area belong to the eastern segment of the CAH. Some radio-collared CAH females calve east of the Canning River in the Refuge in some years (Figure 3-19; Lawhead and Curatolo 1984; Arthur and Del Vecchio 2007; S. Arthur and E. Lenart, ADF&G, personal communication).

Insect Season

Following calving, CAH caribou generally stay within 20 miles (32 kilometers) of the Beaufort Sea coast through the mosquito season (Figure 3-21; Lawhead and Curatolo 1984; Cameron et al. 1995), although movements farther inland have occurred in July in some recent years (Arthur and Del Vecchio 2007; E. Lenart unpublished data). Harassment by mosquitoes, (at least five species of *Aedes*), oestrid flies (warble fly, *Hypoderma tarandi*, and nose-bot fly, *Cephenemyia trompe*) are the dominant influences on CAH caribou movements between late June and early August (White et al. 1975; Roby 1978). Warm and calm weather conditions promote insect flight activity, but insect activity usually is lowest near the coast (Dau 1986) because of the lower air temperatures and higher wind speeds there (Brown et al. 1975; Walker et al. 1980; Parrett 2007). Mosquito-harassed CAH caribou form large groups and move toward the coast until reaching "relief habitat" (Lawhead and Curatolo 1984; Dau 1986; Murphy and Lawhead 2000). 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, often right along the coast (Lawhead and Curatolo 1984; Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 1999e, 2001; Noel and King 2000b, 2000c; Jensen and Noel 2002; Noel and Cunningham 2003; Jensen et al. 2003). In recent years, however, collared caribou from both the eastern and western calving segments of the CAH have traveled east almost to the Canadian border during the insect season (Arthur and Del Vecchio 2007; Lawhead et al. 2009; E. Lenart, ADF&G unpublished data) (Figure 3-22). These large-scale movements may occur anywhere from the coast (if insect harassment is severe) to as much as 20 miles (32 kilometers) inland during periods when insects are inactive due to cool, windy weather; in the latter case, the movements often are back to the west or southwest.

Telemetry studies show that CAH caribou make extensive east-west movements through the Project area in the insect season (Lawhead and Curatolo 1984; Arthur and Del Vecchio 2007; Lawhead et al. 2009). These weather-mediated movements account for the large variability in distribution and abundance (200–2,600 caribou in 1983; 3–5,730 in 1993; 8–2,836 in 1995; 16–1,666 in 1997; 1–2,714 in 1998; 0–2,529 in 1999; 21–2,596 in 2000; 17–5,957 in 2001; 278–11,773 in 2002; and 1–2,427 in 2003) documented on aerial transect surveys in the Bullen–Staines area during the insect season (WCC and ABR 1983; Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 1999e, 2001; Noel and King 2000b; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003). Under mosquito harassment, caribou aggregate and move to the coast throughout the Project area to seek relief. Under continuing harassment, they then may move along the coast in large numbers, and these coastal aggregations can range from a few hundred to several thousand caribou along the entire stretch of coastline in the Project area, 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 1999d, 1999e, 2001; Noel and King 2000b; Jensen and Noel 2002; LGL unpublished data). During intensive radio-tracking in the 1983 insect season, the maximum group size of CAH caribou recorded in the Project area was 2,600 caribou near Bullen Point (WCC and ABR 1983), about 20 percent of the CAH at that time. Most of those animals moved rapidly eastward to the Canning River Delta area within one day (WCC and ABR 1983; Lawhead and Curatolo 1984). The maximal group sizes moving through the Project area are likely to be much larger currently, because of the continuing growth of the CAH.

PH caribou usually do not remain on the coastal plain during the insect season and only move west across the Canning River infrequently during the insect season (Figure 3-21). Of seven periods in the years 1985–1995, the only time satellite-collared PH females occurred west of the Canning River in the Project area was 7 July–14 August, during the post-calving period/insect season (Figure 3-21; Griffith et al. 2002). The typical pattern for PH caribou is for the largest numbers of PH animals to approach the Beaufort Sea coast during the post-calving period and beginning of the insect season (Garner and Reynolds 1986; Russell et al. 1993; Griffith et al. 2002), when mosquitoes predominate. The use of the westernmost portion of the 1002 Study Area in the Refuge by PH caribou peaked during 24 June–14 August (Griffith et al. 2002). In most years, the majority of the PH moves southeast into the foothills and mountains of the Brooks Range as the insect season progresses.

In some years, however, PH caribou may mix with caribou from the eastern segment of the CAH. In such circumstances, very large numbers of caribou may enter the Project area, as occurred during at least one year in the late 1980s. The largest single group of caribou documented to date using the Project area was an aggregation of approximately 20,000 caribou, comprising a mixture of CAH and PH animals (confirmed by radio telemetry), that moved west through the Project area to within 7 miles (11 kilometers) of the Sagavanirktok River Delta during 10–12 July 1988 (Lawhead and Smith 1990). Under mosquito harassment on 13 July 1988, that aggregation returned eastward 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 PH caribou occurred on the summer range, thwarting attempts to complete a photocensus of the CAH (Woolington 1995), and survey coverage of the Project area during the post-calving period in those years was sporadic.

When temperatures cool and mosquito activity abates, 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, harassment by oestrid flies drives caribou to seek relief in a variety of unvegetated and elevated sites (such as river bars, mud flats, dunes, pingos [conical ice core mound], 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 (Arthur and Del Vecchio 2007; Lawhead et al. 2009; E. Lenart, ADF&G unpublished data). PH caribou typically have moved well inland by that time.

Migration and Winter

The decline of mosquito activity in late July and early August marks the beginning of a period of inland dispersal for CAH caribou. In an intensive telemetry study in 1983, radio-collared CAH caribou that summered in the Project area began 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; Sopuck et al. 1986; Murphy and Lawhead 2000; Arthur and Del Vecchio 2007; Lenart 2009a). No winter survey data of caribou are available for the Project area but telemetry locations from February–March 2002–2006 showed only one collared caribou near the Project area (Arthur and Del Vecchio 2007). Since winter 2000–2001, large numbers of CAH caribou have wintered on the south side of the Brooks Range west of Arctic Village (Arthur and Del Vecchio 2007; E. Lenart, ADF&G personal communication).

In contrast to CAH caribou, which have relatively limited seasonal migrations, PH caribou undertake extensive migrations (with some exceeding 3,000 miles [4,820 kilometers] per year) in moving to and from winter ranges south of the Brooks Range in the Yukon and eastern Alaska (Fancy et al. 1989; Russell et al. 1993; Griffith et al. 2002). These extensive seasonal migrations provide hunting opportunities for subsistence hunters from a number of villages, most notably Arctic Village, Old Crow, Aklavik, Fort McPherson, and occasionally Venetie.

In 2003, about a third of the TH (approximately 15,000 caribou at that time) traveled far east of their traditional range and overwintered in the Refuge (Carroll 2007; Person et al. 2007). As noted above, some collared TH caribou moved through the Project area during fall migration in 2003 and spring migration in 2004 (Person et al. 2007) and some TH animals remained with the CAH the following summer (Carroll 2007).

Human Caribou Harvest

Hunting mortality of CAH caribou is relatively light, with the total annual harvest estimated at 604–1,091 animals since the 2000–2001 regulatory year (Lenart 2009a). The total human take includes subsistence harvest by residents of Nuiqsut and, to a lesser extent, Kaktovik, as well as nonsubsistence harvest, which occurs mainly along the Dalton Highway corridor. The harvest in the Project area appears to involve primarily CAH caribou, taken along the coast by residents of Kaktovik.

Throughout its range, the PH is an important subsistence resource for Iñupiat, Gwichin, and Inuvialuit communities in northeastern Alaska and the northern Yukon. Hunting mortality is considered to be relatively light in Alaska, but recent data about harvest in Canada, where the harvest rate is greater, are not available (Lenart 2007a, 2007b). When data were available from both Alaska and Canada (1984–1998), the estimated total annual harvest ranged widely, from 1,584–4,765 animals (Lenart 2007a, 2007b).

Summary

The greatest use of the Project area by caribou occurs between late June and mid-August during the insect season, when large aggregations form and move to and along the coast in response to insect harassment. By far, the Project area is used primarily by caribou from the CAH. Incursions into the area by PH caribou are uncommon and incursions by TH caribou are rare. The density of calving caribou is highest in the southwestern portion of the area between the Staines and Shaviovik rivers from late May to mid-June; relatively few cows calve in the area near the Project facilities. Most CAH and PH caribou breed and winter considerably farther south of the Project area.

3.2.6.2 Muskoxen

Muskoxen are native to northern Alaska, but were extirpated by the mid- to late 1800s (Smith 1989; Reynolds 1998). In 1969 and 1970, muskoxen were returned to northeastern Alaska when animals from Nunivak Island in western Alaska were released at Barter Island and on the Kavik River, southwest of the Project area (Reynolds 1998). Through 1986, the population primarily occupied riparian areas in the Refuge, between the Canning River and the Aichilik River. The population grew 24 percent per year from 1977–1981 and continued to increase at about 14 percent per year from 1982–1986. High rates of calf production and survival contributed to this rapid population growth (Reynolds 1998).

After 1986, muskoxen expanded their range beyond areas first occupied in the Refuge and, by the early 1990s, mixed-sex groups were found as far west as the Colville and Itkillik river drainages and as far east as the Babbage River in the northwestern Yukon, Canada (Reynolds 1998; Reynolds et al. 2002b). Surveys and other observations suggested the total population peaked at about 800 muskoxen in 1995, but the numbers of animals in the regions first occupied slowly declined from 386 in 1986 to 238 in 1995 (Reynolds 1998; Reynolds et al. 2002b).

As the muskoxen range expanded, numbers of animals west of the Refuge increased from 122 in 1990, 156 in 1991, and 330 in 1995 (Lenart 2009b). In 2006, biologists from state and federal agencies flew a census of muskoxen throughout most of the population's range from Fish Creek in the NPR-A to the Babbage River in northwestern Canada (Reynolds 2006). Almost 300 muskoxen were counted on the 2006 survey, but none were observed in the Project area, and only one was observed in the Refuge. An estimated 100 muskoxen were assumed to be east and south of the census area, on the basis of observations by Canadian biologists and others, suggesting that the entire population was likely about 400 animals in 2006 (Reynolds 2006).

The loss of about 50 percent of the population between 1995 and 2006 was primarily because of the disappearance of muskoxen from areas first occupied in the Refuge. Low rates of calf recruitment and adult survival, and movements of muskoxen out of the Refuge caused the decline (Reynolds 2001; Reynolds et al. 2002b). Factors affecting reproduction and survival and shifts in distribution likely included winters with rain-on-snow events and deep snow that reduced access to forage and increased energy costs, the general reduction in quality and quantity of winter forage, and predation (Reynolds et al. 2002a; Reynolds et al. 2002b, Reynolds 2006; ADF&G 2007). The role of disease or parasites on population trends is also being evaluated (Reynolds 2006).

From 2006–2009, the population in northwestern Alaska was relatively stable. During this period, most muskoxen occupied the area west of the Refuge where 192 muskoxen were counted in 2008 and about 200 were estimated in 2009 (Lenart 2009b; Reynolds 2009). Productivity in this western segment of the population appeared high, but recruitment was low and muskoxen could become scarce in the future (ADF&G 2007). During this period, numbers in the Refuge varied from 5–44, depending on the movement of mixed groups living near the refuge (Reynolds 2009). No recent surveys have been done in the northern Yukon, Canada.

Muskoxen in northeastern Alaska are nonmigratory and live year-round on the ACP and adjacent foothills. The muskox is an Arctic species, adapted to surviving long, cold winters and short, cool summers. Unlike caribou (whose calving season occurs when green forage is emerging in early June), most muskoxen give birth from late April to mid-May, when winter conditions prevail (Reynolds et al. 2002b). Reproducing females do not have access to green forage for several weeks and must use stored body reserves to produce milk. Consequently, muskoxen must be fat at the end of winter to reproduce successfully (Reynolds et al. 2002a, 2002b). Energy conservation in winter is a key to survival and successful reproduction.

In winter, muskoxen survive on low amounts of poor quality forage, primarily sedges and grasses. Muskoxen reduce movements and activity in winter and select wind-blown areas or shallow, soft snow for foraging, often on foothill or upland terrain, as energy-conserving strategies (Reynolds et al. 2002b). During summer, when green forage is available and plentiful, muskoxen are more active and occupy larger areas with diverse vegetation. River corridors, flood plains, and foothills are important summer habitats (Reynolds et al. 2002b). Muskoxen must put on body reserves rapidly during the short snow-free season to survive the upcoming winter and to successfully reproduce.

Muskoxen use the Project area only infrequently (Figure 3-23). From 1982–2002, only a few observations of muskoxen were made in the Project area during annual censuses, seasonal surveys, and radio-tracking flights by the Refuge biologists, although muskoxen were found in adjacent drainages (Figure 3-23; Reynolds et al. 2002b). No muskoxen were seen during aerial surveys for caribou in the Project area in May–August 1983 (WCC and ABR 1983) and very few were seen on caribou surveys during June–August (occasionally September) from 1993–1995 and 1997–2003 (Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 2001a; Noel and King 2000b; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003). During the April 2006 census for muskoxen conducted by state and federal agencies, no muskoxen were observed in the Project area (Reynolds 2006), although they were observed elsewhere in the region along the Canning River and Tamayariak River east of the Project site and near the Shaviovik River and smaller drainages west and south of the Badami Development in the westernmost portion of the Project area (Figure 3-23). Small groups of muskoxen were observed on Flaxman Island in 1996 and 1999.

The low frequency of use of the Project area by muskoxen is likely because of the absence of preferred habitat. The area is relatively flat with low-growing vegetation that typically is covered by wind-packed snow in winter. Also, stands of riparian willow or shrubby uplands used by muskoxen in summer are largely absent from the area. The lack of substantial topographical relief or terrain "ruggedness" (where snow cover could be reduced by wind) suggests a lack of suitable winter habitat for muskoxen (Nellmann and Reynolds 1997; Reynolds et al. 2002b).

3.2.6.3 Grizzly Bears

Brown bears (hereinafter grizzly bears) occur throughout northern Alaska, including the Arctic oil fields and the Project area. Compared to other regions of Alaska, grizzly bear densities on the North Slope are low (Miller et al. 1997), and this is primarily because of the short summer season at Arctic latitudes and the consequent low availability of food resources (Miller et al. 1997; Shideler 1998).

Population densities of grizzly bears are lowest on the coastal plain and highest in the foothills of the Brooks Range (Shideler and Hechtel 2000). Recent estimates of density in populations north of the crest of the Brooks Range (mountains and foothills above 1,000-foot elevation, in all drainages from the Anaktuvuk River drainage east to the Canning River drainage) are 18.3 grizzly bears per 386 square miles (1,000 square kilometers) (Becker and Quang 2009). On the coastal plain north of the foothills, including the oil fields and the Project area, the estimated density is much lower: 2.6 bears per 386 square miles (1,000 square kilometers) (Reynolds et al. unpublished report 2004). At four bears per 386 square miles (1,000 square kilometers), the density of grizzly bears in the Prudhoe Bay and Kuparuk River oil field area is higher than in the adjacent undeveloped portions of the coastal plain (Shideler and Hechtel 2000), but still much lower than in the foothills. ADF&G biologists estimate that 60–70 bears inhabited the oil field region, a 6,700-square-mile (17,353-square-kilometer) area between the Colville and Shaviovik rivers and extending inland 50 miles (80 kilometers) to the White Hills (Shideler and Hechtel 2000). The 96 bears captured and marked by ADF&G in the oil fields and adjacent areas during 1991–2000 had large home ranges, averaging 1,190 square miles (3,082 square kilometers) (range 890–1,800 square miles [2,305–4,662 square kilometers]) for adult females and substantially larger for adult males (Shideler and Hechtel 2000). Continuing studies in the area since 2000 have shown similar patterns (Shideler unpublished data). Grizzly bears are highly mobile, moving up to 30 miles (48 kilometers) a day (Shideler and Hechtel 1995a, 1995b, 2000).

Grizzly bears in northern Alaska den from late September to late April or May, and 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, 2000). Females with newborn offspring emerge from dens in early May. Males and females remain separate for most of the year, coming together only briefly to court and mate between May and July (Garner and Reynolds 1986). Grizzly bears 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, 2000). Most of the bears studied by ADF&G denned within 30 miles (48 kilometer) of the oil fields, although a few denned 60–100 miles (97–161 kilometers) inland (Figure 3-24; Shideler and Hechtel 1995b, 2000; Shideler unpublished data).

Grizzly bears use river drainages on the coastal plain as primary travel routes and foraging areas (Figure 3-24; Shideler and Hechtel 1995a, 2000; Johnson et al. 1996, 1997). Riverine habitats contain preferred foods such as legumes (flowering plants in the pea family) and Arctic ground squirrels. In spring and summer, grizzly bears mainly eat plants, but also take ground squirrels, fox pups, caribou, and muskoxen (Quimby 1974; Garner and Reynolds 1986; Shideler and Hechtel 2000). Artificial food sources also are powerful attractants, so human facilities located near rivers are especially likely to attract grizzly bears. Grizzly bears in the Prudhoe Bay and Kuparuk oil fields have larger litters, higher growth rates, and greater body sizes than bears elsewhere on the coastal plain, evidently because of supplemental foods from artificial sources (Shideler and Hechtel 1993, 2000).

Little information is available regarding grizzly bear use of the Project area before the mid-1990s. A few grizzly bear sightings were reported by Alaska Radar System personnel stationed at Bullen Point in the 1970s (LGL et al. 1999) and at least one was seen feeding on caribou calves in 1987 (Lawhead and Cameron 1988). During 1993–2003, five observations of grizzly bears were recorded during overflights of the Project area, all in the western portion between the Badami Development and Point Gordon (Figure 3-24). These bears were recorded during surveys by ADF&G in 1997–1999 (Shideler 1998, 1999) and by LGL and Entrix in 1993, 1995, and 1997–2002 (Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 2001; Noel and King 2000b; Jensen and Noel 2002; Noel and Cunningham 2003; Jensen et al. 2003). Most sightings during those flights were south of the locations of the proposed infrastructure, primarily along small streams draining from the Kavik Hills northward to the Shaviovik River and Badami Development area.

The Project area is at the eastern extreme of ADF&G's oil field study area, so data about collared bears using that area are very limited. Little work was done in the area before 1995, and surveys specifically for grizzly bears in the Project area did not occur until 1997 (Shideler 1998, 1999). Several helicopter surveys were conducted in 1997 to specifically assess grizzly bear use of the area between the Badami development and the Staines River and southward to 69º 55' N latitude (Shideler 1999). Those surveys were discontinued after a single season because of the paucity of bear sightings. Subsequent sightings were obtained by ADF&G during tracking flights in search of marked bears and in bear habitat-assessment work between the Prudhoe Bay oil field and the Refuge. Shideler (1999) concluded that, because of the limited amount of preferred riparian habitat, and the low topographic relief on the ancient alluvial fan that underlies most of the Project area, grizzly bear use of the area is likely to be restricted to movements along the rivers (Staines, Kavik, and Shaviovik) and associated smaller drainages nearby, as well as occasional movements of bears traversing the area between the riparian zones on either side of the Project area. In addition, grizzly bears can be expected to occur along the coast anywhere marine mammal carcasses wash ashore. No collared bears denned in the Project area during 1999–2008 (Figure 3-24; Shideler 1999; Shideler unpublished data).

During 2006, when lemming numbers were very high across the central portion of the coastal plain, including the Canning River Delta and areas west to the Badami Development, three radio-collared bears moved into the Project area (Reynolds et al. 2006; Shideler unpublished data). During this period, one male bear, fitted with a GPS satellite radio collar, foraged extensively on the Canning River Delta and in the eastern portion of the Project area. In May 2007, when lemming numbers had declined, this bear visited Flaxman Island and areas of nearshore ice, but then moved west beyond the Project area for the remainder of the active-thaw season. This pattern of habitat use during years of high lemming numbers in the Project area likely was followed by two other radio-collared bears that primarily use the area near the Sagavanirktok River and perhaps by an unmarked bear that also was observed in the area (Richard Shideler, ADF&G personal communication). Habitat use by bears studied on the coastal plain in the Refuge also was related to snowmelt patterns: in years when snowmelt occurred early (e.g., 1990) or normally (e.g., 1989), radio-collared bears used the coastal plain more they did in years when snowmelt occurred late (e.g., 1988; Young et al. 2002).

Although the Project area presently is open to hunting of grizzly bears, historically very few have been taken there. The estimated grizzly bear population in Game Management Unit (GMU) 26B, which includes Project area, is 269, with a 5 percent allowable harvest of 13 for the entire 15,500-square-mile (40,145-square kilometers) area, but the mean annual harvest for the 10-year period of 1998–2007 was only 8.3 bears (Lenart 2009c). Harvest during the regulatory year ending in 2008 was 23, but if the harvest exceeds 13 during fall 2009, then the department has indicated it will submit a proposal to the Board of Game to restrict the harvest in future seasons (Lenart 2009c).

Arctic Foxes and Red Foxes

Arctic foxes occur across the ACP and are probably the most abundant predatory mammal in the Project area. In contrast, red foxes are uncommon-to-rare in the coastal plain, except along major river drainages, such as the Sagavanirktok and Canning rivers. Recent observations in the Prudhoe Bay oil field have documented increasing numbers of red foxes, the occupation of traditional Arctic fox dens by red foxes (Sanzone et al. 2009), and interspecific competition and predation of Arctic foxes by red foxes (Pamperin et al. 2006; Sanzone et al. 2009). It is possible that red foxes are similarly more common in the far eastern portion of the Project area near the Canning River, but no red fox sightings have been reported during various aerial surveys for mammals in the Project area and no further information is available.

Arctic foxes are opportunistic predators and scavengers and readily exploit locally, seasonally, or artificially abundant food sources. They are readily attracted to areas of human activity and artificial food sources, such as dumpsters or open-pit garbage dumps (Eberhardt et al. 1982; Burgess et al. 1993; Burgess 2000), where their status as a rabies vector raises safety concerns for humans and domestic animals. When not harassed or hunted, Arctic foxes show little natural fear of humans, and they use human structures readily as shelter in all seasons, including as dens during the breeding season (Burgess et al. 1993; Sanzone et al. 2009).

Small mammals (mainly collared and brown lemmings, but also singing and tundra voles and Arctic 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; Burgess 2000). Because rodent populations fluctuate widely, the fox population does also; in some areas of the Arctic, small mammals cycle fairly predictably every three to four years (MacPherson 1969), although this is does not appear to be the case in the central Beaufort Sea region of the ACP.

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 and when birds are absent, foxes mainly eat 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. In villages, construction camps, and developed oil fields, human 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; Burgess 2000). An abundance of artificial foods can lead to increased population sizes and productivity (Burgess 2000) and alter seasonal movements (Pamperin and Follmann unpublished data).

Arctic foxes breed during March or April, and pups are born between May and early July. 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 litter had 13 pups (Burgess et al. 1993). In the region of the Colville River Delta (before oil field development), mean litter size in July was around three pups in most years and increased to around six pups in years when rodents were abundant (Garrott 1980; Johnson et al. 2003); the largest litter recorded was 15 pups in 1996, a year when lemmings were abundant.

Arctic fox pairs maintain exclusive territories around their dens during summer (Eberhardt et al. 1983; Burgess 1984). Dens are occupied from late spring until pups disperse in August (Chesemore 1975). During fall, foxes gradually abandon territorial defense and, depending on food availability, may maintain an undefended home range on the tundra through the winter or may disperse widely, particularly onto the sea ice. Recent evidence verifies early reports that many Arctic foxes travel long distances in distinct seasonal patterns, moving toward the coast and onto the sea ice in fall and back onshore in late winter to early spring (Chesemore 1975; Pamperin et al. 2008). Remarkable long-distance movements by individual Arctic foxes have been documented, including movements of up to 1,600 miles (2,570 kilometers) by foxes marked and released near Prudhoe Bay (Eberhardt and Hanson 1978; Burgess unpublished data; Pamperin et al. 2008). During winter, foxes are less aggressive and usually nonsocial, although they may congregate and interact in areas where food is abundant. Dense aggregations of Arctic foxes may occur locally where food is abundant during winter, such as at marine mammal carcasses and garbage dumps.

Development activities in the Prudhoe Bay oil fields have probably led to increases in fox numbers and productivity (Eberhardt et al. 1983; Burgess et al. 1993; Rodrigues et al. 1994; Burgess 2000; Ballard et al. 2000a, 2000b). The average density of dens over large areas may be up to five times higher in developed portions of the oil fields (one per 5–6 square miles [13–16 square kilometers]) than in undeveloped areas of the coastal plain (one per 8–28 square miles [21–73 square kilometers]) (Garrott 1980; Eberhardt et al. 1983; Burgess et al. 1993; Burgess 2000; Johnson et al. 2003). In addition, both the rate of den occupancy and litter sizes are substantially higher in the oil fields than in adjacent undeveloped areas (Eberhardt et al. 1983; Burgess et al. 1993; Rodrigues et al. 1994). In years of lemming scarcity, the only foxes with litters that survived to late summer were those living near oil field facilities. These effects have been attributed to the availability of garbage as a food source, especially during winter. Recent studies using satellite telemetry indicate the presence of resident Arctic foxes in the oil fields, in contrast to the remarkable nomadic movements of foxes marked in undeveloped areas (Pamperin and Follmann unpublished data).

Fox extirpation efforts have been undertaken periodically to remove foxes from the oil fields when there was a perceived overabundance of foxes (Burgess 2000; Ballard et al. 2000a, 2000b). The main fear is that overabundance of Arctic foxes, especially those that are habituated to humans, increases the risk to humans of rabies and cystic hydatid (e.g., tapeworm) disease. An additional concern regarding the higher densities and reduced population fluctuations of fox populations in the oil fields is the potential impact (increased predation) on nesting shorebirds and waterfowl (Martin 1997; Day 1998; Burgess 2000).

Arctic foxes exhibit strong habitat preferences for denning (Johnson et al. 1999b). Preferred sites include pingos, small mounds, stream and lake banks, and ridges, which presumably are selected for their thin snow accumulations, deep thaw layers, surface stability, and coarse soils (MacPherson 1969; Burgess 2000). These typical dens generally are stable structures that persist for decades (MacPherson 1969), and older dens, which are strongly preferred by foxes, are large, conspicuous structures, often with more than 50 burrow entrances and highly modified vegetation. However, many dens on the coastal plain are less conspicuous and may be newly developing dens or temporary dens not likely to be used in subsequent seasons (Burgess 2000).

Foxes may use the same den site in successive years and, although populations fluctuate widely among years, more dens are available each year than are used. Foxes living in the oil fields also have been reported to den in artificial structures (utility corridors, culverts, abandoned vehicles or heavy equipment, and crawl spaces) (Burgess 2000; Sanzone et al. 2009) 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; Burgess 2000).

Because most den sites have a history of use by Arctic foxes, and because foxes appear to prefer such sites for breeding, den locations can be mapped and the dens censused annually to obtain an index of fox abundance and productivity. Five den-survey efforts have covered part or all of the Project area for Arctic fox dens (Quimby and Snarski 1974; WCC and ABR 1983; Burgess et al. 1993; Rodrigues et al. 1994; Perham 2000, 2001). Only Perham (2000, 2001) conducted systematic surveys of the entire Project area.

As a result of these surveys, 12 Arctic fox dens have been located within 5 miles (8 kilometers) of the coast or barrier islands between the Badami Development and the Canning River (Figure 3-25), an area of approximately 298 square miles (772 square kilometers), yielding an estimated density of one den per 25 square miles (65 square kilometers). Five fox dens are within 1 mile (1.6 kilometers) of the Project facilities. Nearly half of the dens in the area were found in 2000 (Perham 2001), confirming that the relatively small number of dens found in the Project area before that was a result of incomplete survey efforts. Additional fox dens are likely to be found in the Project area with additional search effort.

Another factor influencing the distribution of fox dens is the location of the Project on the ancient alluvial fan of the Canning River, which lacks topographic relief and extensive riparian habitats. Perham (2001) noted that the density of dens in the area between Bullen Point and the Staines River was half that found in his Badami study area farther west. Nevertheless, additional survey efforts in 2000 did reveal more dens (Perham 2001), and the resulting density of Arctic fox dens in the Project area is comparable with that found in the Colville River Delta region, which has been extensively surveyed (Johnson et al. 2003).

The proportion of active dens in the region between the Sagavanirktok and Staines rivers varied little between 1999 (46 percent) and 2000 (52 percent), in contrast to other studies that found substantial annual variation in den activity (Perham 2001). It is likely more years of monitoring would result in a broader range of activity. For example, during 1993–2001, the proportion of active Arctic fox dens in the Colville River Delta region varied from 24 percent in years without significant rodent populations to 67 percent in a year of high lemming abundance (Johnson et al. 2003).

3.2.6.4 Moose

Distribution and Numbers

Breeding populations of moose evidently did not become established north of the Brooks Range until the 1920s, in the eastern portion, and the 1950s, in the western portion of the North Slope (Coady 1980). Today 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; Coady 1980; Lenart 2008a). Densities on the coastal plain are lower than in the foothills. The population in GMU 26B East (extending from the Sagavanirktok River to the Canning River and including the Project area) appeared to have peaked at approximately 600 animals in the late 1980s, subsequently dropping to approximately 150 animals by the late 1990s, evidently because of poor survival of both calves and adults in the early 1990s (Lenart 2008a). The population in this subunit increased subsequently to 300–350 moose by 2007 (Lenart 2008a).

Habitat Use

In winter, riparian habitats along large drainages are especially important, as forage is available only in willow stands that are not covered by drifting snow. Following snowmelt in May, moose disperse more widely across the tundra into smaller drainages. Investigations east of the Project area (in the 1002 Study Area of the Refuge) indicate that, in winter, moose concentrate in the foothills of the Brooks Range along the Canning and Kongakut rivers and, in late spring–early summer, small numbers of moose (generally less than 25 animals) move northward along river drainages, using a variety of riparian habitats (Garner and Reynolds 1986). Moose calve from mid-May to early June and rut during late September and early October. Moose on the North Slope are at the northern limit of their continental range and are susceptible to nutritional stress and starvation during bad winters.

As is true for muskoxen, the lack of preferred riparian habitats throughout most of the Project area limits the occurrence of moose to the western and eastern fringes of the area. No moose were recorded in the Project area during aerial transect surveys for caribou in the 1980s (WCC and ABR 1983; Lawhead and Curatolo 1984; Curatolo and Reges 1985; Lawhead and Cameron 1988). Very few moose were seen on transect surveys for caribou in the Project area and adjacent areas during 1993–1995 and 1997–2003 (Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 2001; Noel and King 2000b, 2000c; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003; LGL unpublished data). Only four bull moose were recorded on transect surveys in the 1990s, all in 1994, in the drainages of the Kavik, Shaviovik, and Kadleroshilik rivers, west of the Project area (Figure 3-23).

Human Moose Harvest

Human harvests of moose declined during the early 1990s because of the general decrease in moose numbers across the North Slope in those years. Because of concerns about the population decline, the state hunting season was closed from fall 1996 until fall 2006 in GMU 26B and has remained close in GMU 26C from the Canning River eastward (Lenart 2008a). A federal subsistence hunt was authorized in 2004 for federal lands in the Refuge, with a harvest limit of three moose (Lenart 2008a). Residents of Kaktovik and Nuiqsut hunt moose as a subsistence resource and residents of each community were estimated to harvest two to six moose annually in GMU 26B and 26C before the season closure in 1996 (Lenart 2008a). Although travel to the area is expensive and logistically difficult, the impacts of sport hunting were considerable before closure, particularly near aircraft landing strips. The total nonsubsistence harvest reported for GMU 26B (which includes the Project area) ranged from 17–52 moose annually during 1986–1995, but has numbered only three–seven moose since the season was reopened in fall 2006 (Hicks 1996; Lenart 2008a).

Other Mammals

In the northwestern portion of the Refuge, wolves occur in the lowest densities on the coastal plain and are much more common in the mountains and foothills; suitable denning habitat is limited on the coastal plain, and no dens were found on the Refuge coastal plain during 1982–2001 (Young et al. 2002). The North Slope population of wolves has remained relatively low since extensive federal predator control occurred in the 1950s and 1960s (R. Stephenson personal communication), but reports by local trappers suggest that the population increased in the 1990s (G. Carroll personal communication). The autumn population density of wolves in the Refuge was estimated at approximately one wolf per 265–280 square miles (686–725 square kilometers) in the mid-1980s (Garner and Reynolds 1986), and the density of wolves in the Project area would be expected to be much lower than that because of the limited occurrence of favorable habitat. Another canid that may occur rarely in the Project area is the coyote. Both wolves and coyotes are associated primarily with productive riparian habitats on the North Slope and, therefore, probably rarely occur in the Project area. Only two sightings of wolves were recorded during caribou surveys between the Sagavanirktok and Canning rivers in 1993–1995 and 1997–2003 (Pollard 1994; Pollard and Noel 1995; Noel 1998; Noel and Olson 1999d, 1999e, 2001; Noel and King 2000b, 2000c; Jensen and Noel 2002; Jensen et al. 2003; Noel and Cunningham 2003). Both sightings, totaling three wolves, occurred in July 1999 in the Kavik River drainage southwest of the Project area (Noel and King 2000c).

Wolverines occur in low densities on the coastal plain and are more common in the foothills and mountains of the Brooks Range (Bee and Hall 1956; Quimby and Snarski 1974; Garner and Reynolds 1986). Even in the foothills and mountains of the Refuge, however, the population density appears to be low, as indicated by the low frequency of sightings during extensive biological survey work in the 1980s (Garner and Reynolds 1986). Denning occurs primarily in the mountains and foothills in areas with deep snow cover. Wolverines are scavengers and occasionally predators of caribou and are found in association with caribou calving and post-calving areas (Garner and Reynolds 1986), suggesting that they may occasionally occur in the Project area during caribou calving season. No wolverine sightings were recorded in the Project area during any caribou surveys from the 1980s to the early 2000s. Although their small body size may limit their visibility to aircraft observers, the total lack of sightings suggests they are present in very low densities.

The ermine and least weasel 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 could potentially occur in the Project area are river otter and mink; however, both species are restricted primarily to major river drainages farther south in the foothills and mountains and therefore are highly unlikely to occur in the area.

Small mammals likely to be found in the Project area include Arctic ground squirrel; collared and brown lemmings; root voles; and barren-ground, tundra, and Alaska tiny shrews. Singing voles may occur along the larger rivers along the eastern and western borders of the Project area but are unlikely to occur in the central portion of the area.

The Arctic ground squirrel is abundant on the ACP, with the highest densities occurring along major river drainages (Bee and Hall 1956; Batzli and Sobaski 1980). Because they live underground, ground squirrels require unfrozen soils that are deep enough for burrowing. Typical habitats are uplands, such as sand dunes, ridges, river banks, bluffs, and pingos. On the coastal plain, ground squirrels are most abundant along major river drainages, so they are likely to be uncommon in the central portion of the Project area. Ground squirrels hibernate from September–May (McLean and Towns 1981; 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 documented), as well as occasional carrion, lemmings, voles, and eggs of ground-nesting birds (Batzli and Sobaski 1980; McLean 1985). Ground squirrels are an important prey species for Golden Eagles, foxes, and grizzly bears (Garner and Reynolds 1986).

The most abundant small mammals captured at several locations in the Refuge were the two species of lemmings and the root vole (Burgess 1984; Babcock 1986; Garner and Reynolds 1986). Lemmings may be the most common small mammals on the ACP, and their numbers fluctuate dramatically, often in a cyclic pattern, although the periodicity of cycles in the central Beaufort Sea portion of the coastal plain is poorly understood. Collared lemmings prefer drier habitats found in tussock tundra and high-center polygons, whereas brown lemmings and tundra voles inhabit wet sedge meadows and low-center polygons. Collared lemmings eat mostly shrubs (willows and mountain avens) and forbs, whereas brown lemmings and tundra voles eat sedges and grasses (Pitelka 1957; Batzli et al. 1983). Root voles are less common than lemmings and tend to be patchily distributed on the ACP. Little is known of the abundance or distribution of shrews on the ACP, although they appear to be widely distributed. The Alaska tiny shrew, a species only recently described, has been recorded on the Canning River Delta (MacDonald and Cook 2009).

3.2.7 Threatened and Endangered Species

The terrestrial portion of the Project area is seasonally occupied by the Spectacled Eider and polar bear, both of which have been listed as threatened under the ESA. Steller's Eiders, also listed as threatened, could occur in the Project area but have not been sighted during recent surveys. The Yellow-billed Loon, which was recently listed as a Candidate species under the ESA, occurs regularly in the nearshore waters in the Project area and has been observed occasionally in the general vicinity, primarily near rivers and river deltas. In addition, the listed bowhead whale migrates offshore of the barrier islands that separate Lion Bay from the Beaufort Sea. In the discussion below for each species, we have provided a history of the listing process, descriptions of historical and current distribution and abundance in the Project area and vicinity, and a brief discussion of life history and habitat use for species that are relevant for discussion of potential project effects on these listed species.

3.2.7.1 Bowhead Whale

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunct circumpolar distribution (Reeves 1980). They are one of only three whale species (the others being beluga and narwhal) that spend their entire lives in the Arctic. Bowhead whales occur in the western Arctic (Bering, Chukchi, and Beaufort seas), the Canadian Arctic and West Greenland (Baffin Bay, Davis Strait, and Hudson Bay), the Okhotsk Sea (eastern Russia), and the Northeast Atlantic from Spitzbergen Island westward to eastern Greenland. The proposed activity will only occur within the range of the Bering-Chukchi-Beaufort Sea (BCB) stock, which is the largest of the four stocks.

The BCB stock of bowhead whales was estimated at 10,400–23,000 animals in 1848, before commercial whaling decreased the stock to between 1,000–3,000 animals by 1914 (Woodby and Botkin 1993). This stock has slowly increased since 1921, when commercial whaling ended, and now numbers at least 10,545 whales, with an estimated 3.4–3.5 percent (greater than 350 animals per year) annual rate of increase (Brandon and Wade 2004; George et al. 2004a, 2004b; Zeh and Punt 2004; Angliss and Outlaw 2008). The most recent published count of 121 calves during the 2001 census was the highest recorded for the population (George et al. 2004a). The high calf count is reflected in a high pregnancy rate and low length at sexual maturity, which is characteristic of an increasing and healthy population (George et al. 2004b). The actual population size is likely higher, because the most recent estimate was derived from data collected in 2001. The current population could be more than 13,000 bowheads, given an annual growth rate (3.4–3.5 percent). Sheldon et al. (2001) suggested that the BCB stock should be delisted under the ESA, because its population is within the range of its pre-commercial exploitation size. George et al. (2004a) concluded that the recovery of the BCB bowhead whale population is likely attributable to low anthropogenic mortality, relatively pristine habitat, and well-managed subsistence harvest. Bowhead whales are an important subsistence resource for residents of the villages along the Chukchi and Beaufort seas.

The BCB stock winters in the central and western Bering Sea and largely summers in the Canadian Beaufort Sea (Quakenbush et al. 2009; Moore and Reeves 1993; Brueggeman 1982). Spring migration from the Bering Sea follows the eastern coast of the Chukchi Sea to Point Barrow in nearshore leads from mid-March to mid-June before continuing through the Western Beaufort Sea through offshore ice leads (Braham et al. 1984; Moore and Reeves 1993). Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June but most may remain among the offshore pack ice of the Beaufort Sea until mid-summer. Bowhead whales calve during spring in the Bering Sea and during the migration. After leaving the Canadian Beaufort Sea, bowheads migrate westward from late August or September to mid- or late October. The tracks of satellite-tagged whales suggest that some whales leave Canadian waters in early October to begin the fall migration (Quackenbush et al. 2009). Fall migration into Alaska waters is primarily during September and October. However, in recent years, bowheads have been seen or heard offshore from Point Barrow to Kaktovik during summer and early fall (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004; Ireland et al. 2009). Consistent with this, Nuiqsut whalers have stated that a small number of the earliest arriving bowheads have apparently reached the Cross Island area earlier (late August) than in past years (C. George, personal communication 2006). Although some whales summer in the Alaska Beaufort Sea, it is likely to represent a small proportion of the total population on the basis of past research and historic accounts. It is not clear if this represents a new trend or is because of increased numbers of whaling crews and researchers in the Beaufort Sea detecting more bowhead whales and other marine mammals.

The MMS has conducted or funded late-summer/autumn aerial surveys for bowhead whales in the Alaska Beaufort Sea since 1979 (Ljungblad et al. 1986, 1987; Moore et al. 1989; Treacy 1988-1998, 2000, 2002a, 2002b). Bowheads tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice (Moore 2000; Treacy et al. 2006). In addition, the sighting rate tends to be lower in heavy ice years and more widespread in light ice years (Treacy et al. 2006). During fall migration, most bowheads migrate west in waters ranging from 49.2–656.2 feet (15–200 meters) deep (Miller et al. 1999). Some individuals enter shallower water, particularly in light ice years, but very few whales occur shoreward of the barrier islands. Survey coverage far offshore in deep water is usually limited, and offshore movements may be underestimated. However, the main migration corridor is widespread over the continental shelf.

Bowhead whales typically reach the Point Barrow area during their westward migration from the feeding grounds in the Canadian Beaufort Sea in mid-September to late October. However, over the years, local residents report small numbers of bowhead whales feeding off Barrow or in the pack ice off Point Barrow during summer. Recent studies have documented bowheads feeding offshore Point Barrow to beyond Smith Bay during late August to mid-September (Goetz et al. 2009). Bowhead whales may feed opportunistically where food is available as they migrate through the Alaska Beaufort Sea. Recent carbon-isotope analysis of bowhead whale baleen suggests the Chukchi and Bering seas may be the predominant feeding areas for adult and juvenile bowhead whales, but this is not universally supported by the scientific community (Schell et al. 1987; Schell and Saupe 1993; Lee et al. 2005). Examination of stomach contents from whales taken in the Iñupiat subsistence harvest indicates that bowhead whales feed on a variety of invertebrates and small fishes (Lowry 1993). Recent analysis of stomachs collected from harvested whales found mainly copepods in whales harvested off Kaktovik and euphausiid-like prey for those harvested off Barrow (Goetz et al. 2009).

Data for 18-satellite-tagged bowhead whales show that most of them appear to complete their annual cycle by migrating across the Chukchi Sea in a westerly direction past Wrangel Island and then down the western coast of the Chukchi Sea to the Bering Sea wintering grounds, although some may migrate across the Chukchi Sea in a more southwesterly direction from Point Barrow (Quakenbush et al. 2009; Miller et al. 1985). Most whales appear to cross the Chukchi Sea between latitudes 71º and 74º N (Quakenbush et al. 2009).

3.2.7.2 Yellow-billed Loon

The Yellow-billed Loon was proposed for listing as threatened or endangered under the ESA on 5 April 2004 and was evaluated by the USFWS, which issued a 90-day finding on 6 June 2007 that found that substantial information was available that a petitioned action may be warranted. This initiated status review for the species (Earnst 2004). The Yellow-billed Loon was considered to be vulnerable because of a combination of a low population size, low reproductive rate, and specific breeding habitat requirements. In 2006, the USFWS and other state and federal partners developed a conservation agreement that allows for collaboration on collecting and refining information about Yellow-billed Loons to guide future management decisions. These decisions may be incorporated into agency actions, such as EIS stipulations (USFWS 2006b). On 24 March 2009, the USFWS determined that listing the Yellow-billed Loon as a threatened or endangered species was warranted, but precluded by other higher-priority listing actions (USFWS 2009). Currently, the Yellow-billed Loon is classified as a candidate species under the ESA, which does not provide any statutory protection, but the UFSWS does encourage cooperation with other state and federal agencies and industry to limit detrimental effects of activities on this species. Given the likelihood that USFWS will request an evaluation of Yellow-billed Loon occurrence in the Project area, we have included this species in this discussion.

Yellow-billed Loons are uncommon breeders on most of the ACP and are common breeders only between the Meade and Colville rivers (Sjolander and Agren 1976; Johnson and Herter 1989; Earnst 2004; Earnst et al. 2005). The Project area is in a part of the ACP that supports low densities of Yellow-billed Loons (less than one individual per 38.6 square miles [100 square kilometers]) (Earnst 2004). No nests of Yellow-billed Loons have been documented in the Project area, but several loons were seen in the early 1980s during fall staging (one bird) and migration (seven birds) by WCC and ABR (1983). Wright and Fancy (1980) also recorded Yellow-billed Loons at their two study plots near Point Gordon and Point Sweeny in 1980. More recently, Rodrigues (2002a, 2002b) recorded Yellow-billed Loons in the Project area during ground-based breeding-bird studies, but no loons were seen on plots or found to be nesting.

Yellow-billed Loons also have been observed on the Canning River Delta to the east of Point Thomson (Martin and Moitoret 1981; Kendall et al. 2003). Low densities (mean density = 0.05 bird per square mile [0.02 square kilometers]) 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; Noel et al. 2000a). Most observations of Yellow-billed Loons in the Project area have been recorded in the nearshore waters between the barrier islands and the mainland, but a few sightings of loons have been recorded onshore, south of Tigvariak Island near the Shaviovik River (Figure 3-26). In summary, the paucity of observations of Yellow-billed Loons in the terrestrial portion of the Project area is not unexpected, as the area is at the eastern range of this species in Alaska, but the nearshore waters in the Project area do support some Yellow-billed Loons during late summer (Noel et al. 2000a; Fischer et al. 2002; Earnst 2004).

Yellow-billed Loons arrive on the breeding grounds on the ACP after the first spring meltwater accumulates on the river channels, usually during the last week of May (Rothe et al. 1983; Earnst 2004) and use openings in rivers, tapped lakes, and sea ice before nesting lakes are available in early June (North and Ryan 1988; Earnst 2004). Nest initiation begins during the second week of June, hatching occurs in mid-July, and broods usually are raised in the nesting lake (Rothe et al. 1983; Earnst 2004). Nests were built on peninsulas, shorelines, islands, or in emergent vegetation, usually in or adjacent to large deep lakes. Yellow-billed Loons typically lay clutches of two eggs and after hatch raise broods on the lakes where they nest, forage in lakes within their territories, and use lakes for escape habitat (Johnson et al. 2001; Earnst 2004). Waterbodies adjacent to nest sites are probably more important than the habitats on which the nests actually are built (Johnson et al. 2001), but the presence of fish in lakes within the territory is critical to providing food to raise young (Earnst et al. 2006).

3.2.7.3 Spectacled Eider

Spectacled Eiders (*Somateria* fischeri) have undergone severe declines in abundance, particularly on the Yukon-Kuskokwim Delta in western Alaska (Kertell 1991; Stehn et al. 1993), which precipitated the petition for listing the Spectacled Eider under the ESA on 10 December 1990. After a status review and comment period, the Spectacled Eider was subsequently listed by the USFWS as a threatened species on 9 June 1993 (USFWS 1993a). Critical habitat was designated for Spectacled Eiders on 6 February 2001, and only Ledyard Bay on the ACP was designated as critical habitat; all other areas of critical habitat were in western Alaska (USFWS 2001a).

The Spectacled Eider has declined by more than 96 percent 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 5,000–7,000 breeding pairs (Larned et al. 2009). Recent estimates suggest that the ACP now supports the main breeding population of Spectacled Eiders in Alaska (USFWS 1996; Larned et al. 2009). Data for the nesting population in the Prudhoe Bay area suggest that it might have declined by as much as 80 percent between 1981 and 1992 (Warnock and Troy 1992; TERA 1993a, 1993b). However, recent estimates for the breeding population across the entire ACP, on the basis of aerial survey counts since 1992, suggest that the Spectacled Eider population is no longer in decline and the population has remained relatively stable; the current mean population growth rate is estimated at 0.988 percent (Larned et al. 2009).

Aerial surveys for Spectacled Eiders were conducted in the Project region in 1994 (Byrne et al. 1994; Day et al. 1995) and during 1998–2002 (TERA 1999, 2000, 2001, 2002a, 2002b; Ritchie et al. 2003). This area has been encompassed by surveys conducted across the entire ACP by USFWS since 1992 (Larned et al. 2009). Surveys of breeding pairs of Spectacled Eiders in the Project region have not been conducted for a sufficient time period to identify discernible trends, but densities in the region (0.03 bird per square mile [2.6 square kilometers]) are lower than those found in other areas in and adjacent to the oil fields (Table 3-31). 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 3-27). No nests of Spectacled Eiders have been found in the Project area during those earlier studies, although breeding in the area was confirmed by the observation of one brood (female with four young) south of Point Sweeny in July 1998 (LGL et al. 1999).

More recently in the Project area, aerial and ground surveys for Spectacled Eiders have been conducted at the Bullen Point SRRS in 1994, 2000, 2002, 2003, 2006, and 2007 (Day et al. 1995; Day and Rose 2000; Ritchie et al. 2003; Schick et al. 2004; Frost et al. 2007; Oasis Environmental Inc. 2009) and 1–14 Spectacled Eiders were observed each year. During those six years of surveys, only one Spectacled Eider nest was found at the Bullen Point SRRS (in 2009), and that nest had already failed before it was found and was only later identified as a Spectacled Eider nest on the basis of feathers taken from the nest (Oasis Environmental Inc. 2008). In general, the Project area is thought to be located at the eastern end of the range for Spectacled Eiders on the ACP, although a few Spectacled Eiders do breed farther east in the Refuge (Canning River Delta, Martin and Moitoret 1981; Okpilak River Delta, Garner and Reynolds 1986). A Spectacled Eider nest was found at the Canning River Delta during a ground survey conducted in 2004 and was reconfirmed in 2005 when an incubating female was observed on the nest (Kendall and Villa 2005, 2006).

Although critical habitat was proposed for Spectacled Eiders on the North Slope by USFWS (2000a), the final ruling did not delineate specific areas for critical habitat on the North Slope, other than Ledyard Bay (USFWS 2001a). Critical habitat was not designated on the coastal plain of the North Slope because habitat, particularly nesting habitat, was not considered to be limiting for this species. The proposal did identify, however, elements of critical habitat that might warrant more scrutiny during oil field planning: (1) all deep waterbodies, (2) all waterbodies that are part of basin wetland complexes, (3) all permanently flooded wetlands and waterbodies containing either water sedge (*Carex aquatilis*), Arctic pendant grass (*Arctophila fulva*), or both, (4) all habitats immediately adjacent to these habitat types, and (5) all marine waters out to 25 miles (40 kilometers) from shore, associated aquatic flora and fauna in the water column, and the underlying benthic community. Many of these habitats are found in the Project area.

TABLE 3-31: ABUNDANCE AND DENSITY OF EIDERS ON THE EASTERN ARCTIC COASTAL PLAIN, INCLUDING THE POINT THOMSON REGION, 1993, 1998–2001

Species/Year	Breeding Pairs		Survey Area	Source
	Number of Pairs	Density of Pairs		
Spectacled Eider				
1993				
Sagavanirktok River to Mikkelsen	50	0.37	136.6	Byrne et al. (1994)
Bay	4	0.07	56.5	Byrne et al. (1994)
Mikkelsen Bay to Staines River	2	0.03	76.7	TERA (1999)
1998	3	0.04	76.7	TERA (2000)
1999	0	0.00	123.5	TERA (2002)
2000	2	0.01	123.5	TERA (2002)
2001				
King Eider				
1993				
Sagavanirktok River to Mikkelsen	81	0.59	136.6	Byrne et al. (1994)
Bay	32	0.57	56.5	Byrne et al. (1994)
Mikkelsen Bay to Staines River	133	1.73	76.7	TERA (1999)
1998	127	1.66	76.7	TERA (2000)
1999	72	0.22	123.5	TERA (2002)
2000	126	0.40	123.5	TERA (2002)
2001				
Common Eider				
1993				
Sagavanirktok River to Mikkelsen	1	0.01	136.6	Byrne et al. (1994)
Bay	1	0.02	56.5	Byrne et al. (1994)
Mikkelsen Bay to Staines River	5	0.25	76.7	TERA (1999)
1998 (inland)	14	0.18	76.7	TERA (1999)
1998 (including coast)	18	0.23	76.7	TERA (2000)
1999 (inland)	75	0.98	76.7	TERA (2000)
1999 (including coast)	1	0.02	123.5	TERA (2002)
2000 (inland)	5	0.04	123.5	TERA (2002)
2000 (including coast)	13	N/A	123.5	TERA (2002)
2001 (inland)	63	N/A	123.5	TERA (2002)
2001 (including coast)				

Notes:
Density is reported in pairs/mi^2
mi^2 = square mile(s)
N/A = Not Available

Spectacled Eiders arrive on the ACP of northern Alaska in late May or early June (Warnock and Troy 1992; Anderson and Cooper 1994; Johnson 1995; Johnson et al. 1996, 1997; USFWS 1996). 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; Johnson et al. 1999a). Nesting begins in mid-June and eggs start hatching in mid-July; males disperse from the area by late June (Warnock and Troy 1992; 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 oil field nested primarily in non-patterned wet meadows within wetland complexes containing emergent grasses (*Arctophila fulva*) and sedges (*Carex* spp.) (Anderson and Cooper 1994; Anderson et al. 2009). Spectacled Eiders in the Prudhoe Bay oil field nested principally in non-patterned wet meadows (Warnock and Troy 1992). During the non-breeding season, Spectacled Eiders are primarily benthic feeders that prefer deeper marine waters where crustaceans and mollusks are available as a food source but, during the breeding season, they forage for crustaceans and other invertebrate prey in shallower ponds and lakes (USFWS 2006a).

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 Spectacled Eiders in the Kuparuk, Milne Point, and Prudhoe Bay oil fields use primarily waterbodies with margins of emergent grasses and sedges, basin wetland complexes, and occasionally deep open lakes (Warnock and Troy 1992; Anderson and Cooper 1994; Troy 1994; TERA 1995). These results demonstrate that brood-rearing (and nesting) eiders are strongly associated with aquatic habitats, particularly coastal habitats when available. When young are capable of flight, Spectacled Eiders move to nearshore marine waters, and then depart the ACP, usually by mid-September, when freeze-up begins. After leaving the ACP, Spectacled Eiders move to molting areas along the western coast of Alaska (Ledyard Bay, Norton Sound) and the eastern coast of Russia (Mechigmenshiy Bay and near the Indigirka and Kolyma river deltas) (USFWS 1996). Spectacled Eiders are found during winter in polynas of the Bering Sea, usually south of St. Lawrence and St. Matthew islands (Petersen et al. 1999).

3.2.7.4 Steller’s Eider

The Steller’s Eider (*Polysticta stelleri*) was petitioned for listing as a threatened or endangered species on 10 December 1990 and was formally listed as a threatened species under the ESA on 11 June 1997 (USFWS 1997). Steller’s Eiders historically nested throughout much of western and northern coastal Alaska and in Arctic Russia, but they currently nest only on the Yukon–Kuskokwim Delta (a few pairs since 1994) and the ACP of Alaska, and in Arctic Russia (Kertell 1991; Quakenbush and Cochrane 1993; Flint and Herzog 1999; Quakenbush et al. 2002a, 2002b). Because of the limited number of observations for Steller’s Eiders during the annual breeding-pair surveys conducted on the ACP, the population index reported by USFWS for those surveys (1986–2006) is 743 individuals (Larned et al. 2009). The Steller's Eider recovery plan estimates the breeding population of Steller's Eiders on the ACP at hundreds or low thousands (USFWS 2002).

Critical habitat was proposed on 13 March 2000 by USFWS for Steller's Eiders on the North Slope, west of the Colville River Delta (USFWS 2000b); no critical habitat was proposed in the Project area. The final ruling on 2 February 2001, however, did not designate any areas on the North Slope as critical habitat (USFWS 2001b). The primary constituent elements of critical habitat for Steller's Eiders identified in the original proposal were small ponds and shallow water habitats (particularly those with emergent vegetation); moist tundra within 326 feet (100 meters) of permanent surface waters, including lakes, ponds, and pools; the associated aquatic invertebrate fauna; and adjacent nesting habitats (USFWS 2000b). The preferred habitats of Steller's Eiders near Barrow are waterbodies with pendant grasses (*Arctophila fulva*) (Quakenbush et al. 2000; Obritschkewitsch et al. 2001).

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; Quakenbush et al. 1995, 2002a, 2002b). Non-breeders 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 U.S.–Canada border (Quakenbush et al. 2002a, 2002b). Steller's Eiders have not been recorded in the Project region, but have been seen periodically in the Prudhoe Bay area (Quakenbush et al. 2002a, 2002b). Given that the Project area is well to the east of the normal range for Steller's Eiders, this area is probably not used at all by this threatened species.

Steller's Eiders arrive on the North Slope in pairs in early-June, but eiders breeding in the Barrow area are influenced by the occurrence and abundance of lemmings and their predators (Deering 2002; Quakenbush et al. 2004; Rojek 2008). Since 1999, Steller's Eiders have nested at Barrow in only 6 of 11 years (Rojek 2008; USFWS unpublished data). The preferred habitats of Steller's Eiders near Barrow are waterbodies with pendant grass (*Arctophila fulva*).

After breeding is completed, Steller's Eiders move to marine waters, where they molt and are completely flightless for three weeks (USFWS 2008a). Molting and wintering flocks of Steller's Eiders gather in protected lagoons and bays, feeding on mollusks and crustaceans in shallow water.

3.2.7.5 Polar Bear

<u>Legal Status</u>

Polar bears are managed by USFWS and protected in accordance with three federal laws. The polar bear was designated a protected species under the MMPA of 1972, as amended, and it was listed in 1975 as an Appendix II species under the Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna in 1975. In response to a February 2005 petition to list the species under the ESA, the USFWS undertook a status review and issued a proposed rulemaking on 9 January 2007 (72 FR 1064). USFWS issued a final rule to list the polar bear as a threatened species under the ESA on 15 May 2008 (73 FR 28212). Listing the polar bear under the ESA automatically resulted in the designation of its various populations as strategic stocks under the MMPA. In a special rule developed under the terms of ESA Section 4(d) and published on 16 December 2008 (effective 15 January 2009; 73 FR 76249), the Secretary of the Interior retained the regulatory requirements of the MMPA and CITES as the primary conservation provisions for the polar bear, although the consultation requirements under Section 7 of the ESA still apply for activities potentially affecting the species.

In reaching its decision to list the polar bear as threatened, USFWS analyzed five factors potentially affecting the polar bear, as required by ESA Section 4(a): (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) adequacy of existing regulatory mechanisms; and (5) other manmade or natural factors affecting its existence, such as contaminants, human interactions, industrial development, and tourism (Schliebe et al. 2006). The ESA listing decision was based primarily on the first of these factors, focusing on the threat to polar bear habitat posed by the recent trend for rapidly diminishing sea-ice cover and thickness in the Arctic Ocean, primarily during summer (Durner et al. 2009). The continuing loss of sea-ice habitat was judged to put polar bears at risk of becoming endangered throughout their range in the foreseeable future, meeting the criterion established by the ESA for designating a threatened species.

The listing decision deferred designation of critical habitat until more information was available, but, in response to a lawsuit and settlement agreement, the USFWS agreed to release a proposed rulemaking on critical habitat in fall 2009 and a final rule by 30 June 2010. The rule proposing to designate critical habitat was announced on 22 October and was published on 29 October 2009 (74 FR 56058). USFWS proposed to designate 200,541 square miles of critical habitat in northern and western Alaska, comprising three units corresponding to the "primary constituent elements" of (1) sea-ice habitat over the continental shelf (to 984 feet [300 meters] depth; 192,928 square miles); (2) terrestrial denning habitat (5,668 square miles of suitable terrain within 5 miles [8 kilometers] of the Beaufort Sea coast west of the Kavik River and within 20 miles [32 kilometers] of the coast east of the Kavik River); and (3) barrier island habitat (4,089 square miles within 1 mile [1.6 kilometers] of the mean high-tide line on barrier islands and associated coastal spits).

Distribution and Population Status

Polar bears have a circumpolar distribution in the Northern Hemisphere, primarily around the rim of the Polar Basin and into the seasonally ice-covered regions of contiguous seas. In Alaska, they occur most commonly within 200 miles (320 kilometers) of the Arctic Ocean coast (Amstrup and DeMaster 1988).

Nineteen semi-discrete subpopulations (stocks) of polar bears have been identified throughout the species range (Schliebe et al. 2006; Amstrup et al. 2007) which were estimated to total 20,000–25,000 animals range-wide in 2006. These stocks vary from a few hundred to a few thousand animals each (Stirling 2002; Schliebe et al. 2006). Bears from three stocks occur in Alaska waters: (1) the Northern Beaufort Sea (NBS) stock, which occurs primarily in northwestern Canada; (2) the Southern Beaufort Sea (SBS) stock, which occupies the Beaufort

Sea off the northern coast of Alaska (including the Project area); and (3) the Chukchi Sea stock, which occupies the Chukchi and Bering seas off northwestern Alaska (Bethke et al. 1996; Amstrup 2003a; Schliebe et al. 2006). The ranges of the 19 stocks of polar bears have been grouped into four ecoregions (Convergent, Divergent, Archipelago, and Seasonal Ice), based on the characteristics of sea ice and population movements (Amstrup et al. 2007).

The SBS stock occupies the Divergent ecoregion, where annual ice is formed but is exported to other ecoregions or else melts and retreats to the central portion of the Polar Basin; polar bears in this ecoregion may move with the retreating ice or abandon it to spend the summer on land (Durner et al. 2009). The SBS stock ranges over an area of more than 350,000 square miles (906,500 square kilometers), extending from the vicinity of Cape Bathurst, Northwest Territories, on the east to Icy Cape and Point Hope on the Chukchi Sea coast in Alaska on the west, and seaward about 185 miles (300 kilometers) from the coast (Amstrup 1995, 2000, 2002; Bethke et al. 1996; Brower et al. 2002; Schliebe et al. 2006). There are some indications that the range of the SBS stock may have contracted in recent years (USFWS 2009a). The core activity area of the SBS stock encompasses a considerably smaller region from Herschel Island, Yukon, to Point Barrow, Alaska, and seaward about 85 miles (135 kilometers) (Amstrup 1995, 2000). The Project area is located within the core range of the SBS.

The SBS and Chukchi Sea stocks overlap considerably in the northeastern Chukchi and southwestern Beaufort seas (Amstrup et al. 2005; Schliebe et al. 2006; USFWS 2009a). While not as extensive as with the Chukchi Sea stock, the amount of overlap of the SBS stock with the NBS stock in the eastern Beaufort Sea is substantial (Amstrup et al. 2005; Schliebe et al. 2006). Genetic studies have found insignificant differentiation among the NBS, SBS, and Chukchi Sea stocks, indicating consistent genetic exchange among these stocks despite considerable fidelity to range areas by individual collared bears and suggesting that they may represent a single breeding population (Cronin et al. 2006). Nevertheless, they are managed as separate stocks on the basis of the demographic and movement data that demonstrate range fidelity.

The SBS stock was estimated at 1,526 animals (95 percent confidence interval 1,211–1,841) in 2006 (Regehr et al. 2006); the most recent SBS stock assessment (FR 2009) used that figure to estimate a minimum population size of 1,397 animals (USFWS 2009a). The 2006 estimate represented the mean of three annual estimates from the period 2004–2006, which did not differ significantly (Regehr et al. 2006). The 2006 estimate was lower than the first estimate of the SBS stock, which was 1,778 animals during the period 1972–1983 (Amstrup et al. 1986). The population increased during the 1980s and is thought to have remained stable during the 1990s (USFWS 2009a). The minimum population size in 2002 was calculated as 1,973 animals, based on an estimate of up to 2,272 animals in the SBS population in 2001 (USFWS 2009a). Because the various estimates were derived using somewhat different methods and because the confidence intervals around the estimates overlap, they cannot be considered statistically different (Regehr et al. 2006). The best information currently available, however, suggests that the SBS population is now declining (USFWS 2009a).

Although analysis of recent population trends did not show a statistically significant decline during the period 2001–2006, annual survival rates of cubs of the year and recruitment of yearlings were lower, and body size of subadult bears and adult females declined from earlier periods. These factors suggest reduced nutritional status and a declining population (Regehr et al. 2006; Rode et al. 2007, 2009). Such declines have been linked previously in the polar bear population of western Hudson Bay, Canada (Stirling et al. 1999; Stirling and Parkinson 2006), where similar declines in body condition, size, and cub survival were noted in the years before a significant decline in population was observed (Regehr et al. 2006; Obbard et al. 2007; Rode et al. 2007, 2009).

During the 20th century, polar bear populations in Alaska rebounded after two periods of excessive hunting. The SBS population increased substantially from its most recent historic low in about 1972 (Amstrup 1995, 2002). That low resulted from about 20 years of guided sport-hunting, which employed small airplanes to cover large areas of sea ice in search of bears (Amstrup 1995). A previous historic low may have occurred around 1910–1920 (J.J. Burns, personal communication 2003), resulting from a prolonged period of extensive vessel-based commerce that included early commercial Yankee whalers, coastal traders, sojourners, explorers, scientists, and subsistence hunters (Leffingwell 1919; Bockstoce 1986; Amstrup 2000). Coastal traders actively hunted and bartered for polar bear skins during periods when fur prices were high (J.J. Burns, personal communication 2003). Commercial whaling essentially ended in 1914 (Bockstoce 1986; Bockstoce and Burns 1993) and small-vessel coastal trading declined during the 1920s and ended in the early 1930s.

Reproduction and Survival

Polar bears are long-lived, reaching reproductive maturity relatively late in life, and have relatively few young, an extended period of maternal care, and comparatively high survival rates, especially after attaining maturity (Amstrup 2003). Amstrup (2000, 2003b) and Stirling (2002) provided synoptic accounts of the reproductive cycle, from which the following information is summarized. The onset of sexual maturity (first breeding) may occur as early as 4.5 years of age, but most females of the SBS population probably achieve sexual maturity at about 5.5 years of age (Schliebe et al. 2006). Mating occurs primarily from March to late May or early June, when both sexes are active on the sea ice. Males are about twice the size of females and there is intense competition among males for estrous females. Polar bears are polygamous; a male will remain with a receptive female only for a short time and then seek another female. During the breeding season, males actively seek out females by following their tracks on the sea-ice. Adult males and non-pregnant females are active all year, using dens only as temporary shelter during severe weather.

Some pregnant females of the SBS population construct and enter natal dens in October, but most do so in mid- to late November (Amstrup and Gardner 1994). Birth occurs in maternal dens, typically in late December or early January. The newborn cubs are highly undeveloped, weighing a bit over a pound (0.5 kilogram). Mothers and cubs emerge from natal dens in late March or early April, when the cubs are about three months old and weigh up to 22–26 pounds (10–12 kilograms) (Lentfer and Hensel 1980; Amstrup and Gardner 1994; Smith et al. 2007). They remain near the den for up to two weeks (Smith et al. 2007) as the cubs become acclimated to outside temperatures, then begin traveling on the sea ice. Females that den on land move onto the sea ice to hunt. Cubs usually stay with their mothers until they are 1.5–2.5

years old, although some may remain into their third or fourth year (Stirling et al. 1975). Females breed again at about the same time they separate from their young; thus the breeding interval of females that successfully wean cubs is three years or longer.

The most common litter size is two, followed by one; although infrequent, triplets are not rare. Females in their prime years, ages 8–18, have the largest litters and the heaviest cubs. In populations that are not overexploited, such as the SBS, females live to the mid-20s, with maximum longevity in the late 20s and early 30s. Males live to their early 20s and occasionally to the late 20s (Amstrup 2000, 2003b; Stirling 2002).

The long duration of research on the SBS population — more than 40 years — has provided data during a period of changing climatic and sea-ice regimes and expanding industrial development on the North Slope. Amstrup (1995, 2000, 2002) noted several population parameters that changed between phases when the population was declining (1967–1974) and when it was increasing (1981–1992). During the population low, the number of young per female in the population as a whole was about 0.4, there was a greater frequency of more than one yearling with females, the reproductive interval of 3.4 years was shorter, and the age structure of the population was younger. During later years of the research, there were fewer young per female (less than 0.38), fewer litters of more than one yearling, the reproductive interval had increased to 3.7 years, and there was a higher proportion of older animals. Those data suggested density-dependent changes in a population approaching or reaching carrying capacity.

Recent research has focused on changes in population status and survival as a consequence of diminishing habitat. The reported survival of SBS cubs in the 1980s and early 1990s was 65 percent and that of yearlings was 86 percent; survival of adult females was 96 percent (Amstrup 1995). Regehr et al. (2006), found that, despite higher production of cubs, cub survival over summer was significantly lower in the period 1990–2006 than in the period 1967–1989; cub survival in the later period was estimated at 43 percent and adult survival (all ages of both sexes older than cubs) was estimated at 92 percent. Further analysis of a short-term data set suggested that survival of adult females decreased from 99 percent in 2001–2003 to 77 percent in 2004–2005 (Regehr et al. 2007).

Habitat Use

Although they are classified as marine mammals and are strong swimmers, polar bears rely principally on the availability of sea-ice habitats to provide a substrate on which to roam, hunt, breed, den, and rest. They use island and coastal mainland habitats as well as sea ice, but Amstrup (2003b) noted that only 975 (7 percent) of 14,622 weekly locations of polar bears equipped with satellite collars during 1985–2001 were on land, and most of those were for denning females. Some polar bears also occur on or transit the multi-year ice at very high latitudes (Stirling 2002). Preferred habitats are located in the active seasonal ice zone that overlies the continental shelf and associated islands and in areas of heavy offshore pack ice (Stirling 1988; Durner et al. 2004, 2009). Adult males usually remain there, rarely coming ashore (Amstrup and DeMaster 1988). Habitat use changes seasonally with the formation, advance, movement, retreat, and melt of sea ice (Amstrup et al. 2000; Ferguson et al. 2000;

Durner et al. 2004, 2009; Schliebe et al. 2008). During winter and spring, polar bears tend to concentrate in areas of ice with pressure ridges, at floe edges, and on drifting seasonal ice at least 8 inches (20 centimeters) thick (Stirling et al. 1975, 1981; Schliebe et al. 2006); the greatest densities occur in the latter two categories, presumably because those habitats offer bears greater access to seals. Use of shallow water areas is greatest in winter, in areas of active ice with shear zones and leads (Durner et al. 2004). Use of landfast ice increases in spring during the pupping season of ringed seals. Multi-year ice is selected in late summer and early autumn as the pack ice retreats to its minimal extent (Ferguson et al. 2000; Durner et al. 2004). Prey availability may not be the only factor affecting habitat selection; females with young may retreat to the safety of areas with less prey but greater stability in ice cover (Mauritzen et al. 2003).

Polar bear distribution is influenced primarily by prey abundance on seasonal ice (Smith 1980). The primary prey of polar bears in the Beaufort Sea is the 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. To a lesser extent, bears prey on bearded seals, walrus, and beluga whales, and also feed on carrion, including whale, walrus, and seal carcasses found along the coast (Amstrup 2003b; Schliebe et al. 2006). They occasionally eat small mammals, bird eggs, and vegetation when other food is not available. Polar bears are extremely curious and opportunistic hunters and may approach human developments in search of food.

The nature and dynamics of the seasonal ice cover play an important role in the ecology of marine mammals (Burns 1970; Fay 1974; MMS 2003). Different features of the varied types of dynamic ice cover either accommodate or exclude marine mammals, depending on the species and ice conditions. From the onset of freeze-up in the Project area (October in Lion Bay) to the onset of melting (late May–June) and retreat from the coast (July), a sequence of different snow and ice conditions affects the local abundance of various marine mammals. Five general habitat types for marine mammals occur in the Project area:

- The nearshore Beaufort Sea proper (north of the barrier islands),
- A linear series of protective barrier islands,
- An extensive shallow coastal lagoon,
- Two relatively wide and three narrow entrances to the lagoon, and
- The mainland coast.

Although polar bears may be encountered year-round in nearshore and coastal areas (Amstrup 1995, 2000, 2002; Schliebe and Evans 2002), they usually are absent from the Project area in early summer. They use all five generalized habitats at some time during the year, however, depending on the season and the presence or absence of sea ice, prey, and beach-cast carrion.

Maternal Denning

The Beaufort Sea is an area of widespread, low-density denning in comparison with known denning concentration areas in other parts of the species range (Amstrup 2003b; Schliebe et al. 2006). The main area of terrestrial denning for the SBS stock is located along the coast between Point Barrow and Barter Island, including the barrier islands and a coastal strip extending up to 25 miles (40 kilometers) inland (USFWS 2009a).

Pregnant polar bears excavate maternal dens in compacted snow drifts adjacent to coastal banks (barrier islands and mainland bluffs), river or stream banks, and other areas with at least 4 feet (1.3 meters) of vertical topographic relief (Amstrup and DeMaster 1988; Durner et al. 2001, 2003, 2006). Dens often are located at the edge of stable sea ice on the shoreward side of barrier islands. In particular, Flaxman, Pingok, Cross, Cottle, and Thetis islands are known to support maternal dens along the central Beaufort Sea coast. Onshore, most maternal dens are located in drifts along the coastline and, to a lesser extent, along river or stream banks, but a few have been found along lakeshores and even at the edge of an abandoned gravel pad (Durner et al. 2003). The common characteristic among suitable denning habitats is the presence of topographic features that catch and hold blowing snow in early winter.

Using a combination of methods, USGS biologists characterized and mapped potential denning habitat along the Alaska Beaufort Sea coast between the Colville River and the border with Canada (Durner et al. 2001, 2003, 2006). They delineated and quantified potential habitat using remote sensing, air-photo interpretation, and ground-truthing, correctly classifying about 90 percent of the potential habitats mapped. In two separate analyses, they mapped 1,170 miles (4.4 square miles or 0.18 percent) of potential habitat in a 2,446-square mile study area between the Colville and Tamayariak rivers (Durner et al. 2001) and 2,250 square miles (9 square miles or 0.29 percent) in a 3,087-square mile study area of the coastal plain in the Refuge (Durner et al. 2006).

The Project area is located in a section of coastline that has the least amount of potential denning habitat in the entire area mapped by the USGS (Figure 3-28), although there is one area of local concentration. Flaxman Island is the area of greatest recurring use for denning in the Project area. A sample of 43 terrestrial maternal dens were documented between 1973–2009 in the coastal area (and extending inland 30 miles) between the Shaviovik River and the eastern edge of the Canning River Delta (Figure 3-28). This sample includes dens found by tracking radio-collared females as well as dens encountered opportunistically and, although it is not an exhaustive catalog of all polar bear dens in the area, it reveals some consistent patterns of use. Fifteen of the dens were located on Flaxman Island and one was on Duchess Island, 11 were on the Canning River Delta, and five were near the coast west of Point Thomson. Although the number of polar bears denning in the Project area within a given year cannot be estimated with confidence, it is likely to be low, judging from the existing data on den locations. The occurrence of dens in the area may increase in future years, however, as a result of continuing shifts in denning from drifting sea ice to land by the SBS stock.

Until the latter part of the 20th century, most maternal dens were found largely by ground-based observers in mainland or landfast-ice habitats, so it generally was thought that most denning occurred on land, even though local environmental knowledge of Alaska Native hunters recognized that maternal dens also occurred on drifting ice (USFWS 1995; Kalxdorff 1997; J. J. Burns, personal communication 2003). Lentfer (1975) challenged this predominant view when he confirmed that denning occurred, to an unknown extent, on drifting ice. That discovery led to an important reconsideration of the extent of potential denning habitat. Subsequent radio-telemetry studies have provided quantitative data about maternal denning in all habitats and have confirmed that a high proportion of dens occur on the drifting pack ice, often far from shore.

Of 90 dens located during 1981–1991 in the Beaufort Sea region, 48 (53.3 percent) were on drifting pack ice, 38 (42.2 percent) were on land, including barrier islands, and four (4.5 percent) were on landfast ice (Amstrup and Gardner 1994). Dens on land occurred mainly in a narrow band along the coast, although one was 38 miles (61 kilometers) inland. Amstrup (2003b) summarized similar information about 186 maternal dens located in his Beaufort Sea study area between Point Hope, Alaska and the Mackenzie River in northwestern Canada (167–137° W longitude) from spring 1982–2003 (including some of the same dens reported about by Amstrup and Gardner [1994]). Of those 186 dens, 90 (48.4 percent) were on drifting ice and 96 (51.6 percent) were on land or landfast ice. The most recent analysis of den locations used by collared bears has documented notable shifts in the distribution of maternal dens in northern Alaska (Fischbach et al. 2007). That study compared 124 den locations used by 85 collared bears of the SBS stock between an early period (1985–1994) and a later period (1997–2004). The analysis documented a landward and eastward shift in maternal denning, including the area between the Sagavanirktok and Canning rivers, in which the Project area is located. The proportion of dens located on drifting pack ice decreased from 62.3 percent in the early period to 37.1 percent in the later period, and proportionately fewer dens on pack ice occurred in the western Beaufort Sea in the later period.

In all of the studies described above, the proportion of dens located on land increased through time; a similar increase in denning on land by the adjacent NBS population also has been noted in Canada (Stirling and Andriashek 1992). The increasing proportion of bears denning on land in the Beaufort Sea region was initially attributed to the restriction of hunting after 1972 (Stirling and Andriashek 1992; Amstrup and Gardner 1994); more recently, the landward and eastward shift in denning by SBS bears has been related to reductions in stable sea-ice cover and delays in autumn freeze-up (Fischbach et al. 2007). Because of their greater proximity to settlements, industrial sites, and coastal areas of human activity, dens on land and landfast ice are presumed to be more vulnerable to human-induced disturbance.

Female polar bears have not been found to exhibit fidelity to specific locations for denning, but they tend to den on the same type of substrate (pack ice or land) from year to year and may return to the same general area to den (Amstrup and Gardner 1994; Amstrup 2003b; Schliebe et al. 2006; Fischbach et al. 2007). Along with the landward and eastward shift in denning in recent years, however, Fischbach et al. (2007) noted that more females shifted to land in both the early and later periods of life and that females in the later period showed greater fidelity to land as a denning substrate.

Considering dens on all substrates, Amstrup and Gardner (1994) concluded that denning and cub births in the Beaufort Sea region were sufficient to account for the estimated size of the SBS population at that time: approximately 140 dens per year in a population estimated at 1,500–1,800 animals. Cub production did not differ between females using dens on pack ice and those denning on land or landfast ice, although the risk of cub loss was considered to be greater for dens on the drifting pack ice (Amstrup and Gardner 1994).

Movements

Polar bears of the SBS stock cover large areas during the year, with total annual movements ranging from 874–3,854 miles and covering annual activity areas of 2,805–230,426 square miles (Amstrup et al. 2000). Monthly movements ranged from 49–261 miles over areas of 34–3,768 square miles, with the largest total monthly movements occurring during early winter and the smallest in early spring. Females with cubs move less and cover smaller areas than do other sex and age classes. Movements appear to be increasing as sea-ice cover continues to diminish, however, from 1979–2006, female polar bears moving from the pack ice to denning areas onshore have experienced an average annual increase in travel distance of greater than 3.73 miles per year; greater than 104.4 miles over 28 years (Bergen et al. 2007). Increased frequency of long-distance swimming by collared bears (G. Durner, personal communication 2009), observations of swimming bears and dead bears in open water (Monnett and Gleason 2006; Schliebe et al. 2006), intraspecific predation and cannibalism (Amstrup et al. 2006), and unusual predation attempts (Derocher et al. 2000; Brook and Richardson 2002; Stirling et al. 2008) all indicate increasing difficulty dealing with ecological changes resulting from declining sea-ice cover.

Some polar bears begin to appear on the mainland and barrier islands in increasing numbers in August, during the open water period. By the time of minimal ice extent in mid- to late September, the pack ice can be very far from shore (Treacy 1988–2002b; Miller et al. 2006; Schliebe et al. 2008). As seasonal ice forms and pack ice spreads southward in the late fall and winter, other bears move with it, appearing along the Beaufort Sea coast (Lentfer 1972; Amstrup et al. 2000). Some polar bears may remain on pack ice all year if there is continuous access to prey (Stirling 2002). Polar bears typically use land only during late summer, autumn, and the maternal denning season in winter. Besides denning females, females with cubs and subadult males occasionally come ashore. Beach-cast carrion can be particularly important food sources for subadults and sows with cubs (USFWS 1995; Miller et al. 2006). Except for pregnant females that remain to den, bears begin to leave the coast when sea ice develops, usually by late October (Schliebe et al. 2001; Kalxdorff et al. 2002), although they remain relatively near shore in winter compared with late summer and fall, when ice is farthest from shore (Amstrup et al. 2000). Females with young cubs may hunt in areas of landfast ice after den emergence.

Although polar bears could occur in the Project area at any time of year, there are periods when the probability of their presence is low. The data about their presence or absence are pieced together from a number of sources. Pregnant and subsequently post-parturient females can be present in dens, although not obvious, from late November–early April, most commonly on or close to the barrier islands (Amstrup 2002). Non-denning bears can be expected to roam through the area during those same months, although their preferred hunting habitat in winter and spring is farther seaward in areas of more active ice. The lowest probability of presence in the Project area is from May–July or early August, although that probability may increase as more bears spend time on land in response to shrinking summer sea-ice cover. Stirling (2002) noted that the greatest proportion of a polar bear's total annual caloric intake occurs during spring and early summer when newly weaned ringed seal pups, on which they prey extensively, are very fat. Ringed seal abundance in the Project area is low, and the few that occur there presumably depart when the sea ice melts in summer.

As stated by several Alaska Native residents (Local Environmental Knowledge [LEK]) in USFWS 1995), bears become increasingly abundant on the mainland and barrier islands before (August) and during the fall open water and whaling season. Aerial surveys for bowhead whales conducted by MMS along the coast and offshore have provided numerous incidental sightings of polar bears (Figure 3-28). Aerial surveys conducted during August–October since 2000 along the Beaufort Sea coast between Point Barrow and the Canadian border normally detect about 50–100 polar bears per survey (maximal count was approximately 125); 82 percent of the total sightings have occurred on barrier islands, 11 percent on the mainland, and 6 percent on landfast ice (T. Evans 2009, USFWS personal communication). Peak numbers generally occur in late September–early October (USFWS 1995; Schliebe et al. 2001, 2008; Kalxdorf et al. 2002). More individual polar bears probably move through the Project area at that time, when bears are present along the entire Beaufort Sea coast from Demarcation Point to Point Barrow. Polar bears congregate on the barrier islands in the fall and winter (Figure 3-28) because of available food such as bowhead carcasses and favorable environmental conditions (Miller et al. 2006; Schliebe et al. 2008). In November 1996, a congregation of 28 bears was observed near a carcass on Cross Island, and another 11 were observed within 2 miles (3.2 kilometers) of a carcass on Barter Island (Kalxdorff 1998). Such concentrations have become commonplace and bear numbers have increased in autumn in certain locations (Miller et al. 2006; Schliebe et al. 2008). The greatest concentrations now occur at Barter Island, Cross Island, and Point Barrow, where bears are attracted to and feed on bone piles of butchered bowhead whales taken during the autumn subsistence hunt (Miller et al. 2006; Schliebe et al. 2008). The Project area is located between Cross and Barter islands, but there is little indication of bear movement between those sites (Miller et al. 2006). These occurrences are classic cases of attraction to regular and sizable food sources, resulting in modification of activity patterns during the ice-free season and increasing tolerance of (perhaps habituation to) the structures, noises, and activities associated with nearby communities.

Occasionally, polar bears make relatively long excursions inland. Hunters from Kaktovik reported a den near Sadlerochit Springs, about 45 miles (72 kilometers) inland from the coast (Bee and Hall 1956). On the Chukchi Sea side of the North Slope between the latitudes of Barrow and Wainwright, a polar bear was seen about 50 miles (80 kilometers) inland by the members of a seismic exploration crew (H. Reynolds, ADF&G, personal communication 2003); the date and coordinates of that sighting are not known. A fat female was killed on the West Fork of the Sagavanirktok River, about 100 miles (160 kilometers) from the ocean, in September 1944 by George Wood, an Iñupiaq hunter (Bee and Hall 1956). In September 2002, a lone bear traveled inland along the Sagavanirktok River and was seen repeatedly as it wandered close to the Dalton Highway; by late September, it was about 120 miles (195 kilometers) inland from Prudhoe Bay. It began moving north again in October and was last seen near Sagwon Bluff (R. Shideler, ADF&G, personal communication, 2003). The longest inland movement by a polar bear was documented in March 2008, when a subadult male was killed at Fort Yukon, 250 miles (400 kilometers) from the Beaufort Sea coast (Smetzer 2008; Mowry 2008).

Management and Human Polar Bear Harvest

Polar bears live in areas under the jurisdiction of five nations — Russia, Norway, Denmark, Canada, and the United States — and also in international waters where jurisdiction is not clearly defined. Representatives of these five nations prepared the international Agreement on the Conservation of Polar Bears and Their Habitat in November 1973, which was ratified in 1976 (USFWS 1995; Schliebe et al. 2006). It allowed bears to be harvested only in areas where they were taken by traditional means in the past and it prohibited the use of aircraft and large motorized vessels in polar bear hunting. The agreement created a high seas polar bear sanctuary but did not prohibit hunting from the ground using traditional methods.

The three stocks of polar bear that occur in Alaska are shared with Canada (SBS and NBS stocks) and with Russia (Chukchi/Bering Sea [CBS] stock). Bears from the SBS stock are hunted in both western Canada and northern Alaska. In 1988, the NSB Department of Wildlife Management (representing Alaska Natives) and the Inuvialuit Game Council (representing Canadian First Nations) signed a user-to-user accord between indigenous peoples of Canada and Alaska to provide for coordinated management of the Beaufort Sea stocks. According to terms of the Polar Bear Management Agreement for the Southern Beaufort Sea (Brower et al. 2002), the recommended annual quota during different periods was 76 from 1988–1989 to 1993–1994, 77 from 1994–1995 to 1996–1997, and 80 in 1997–1998. In addition to annual hunting quotas, the agreement provided for the establishment of specified hunting seasons, protection of bears constructing or occupying dens, and protection of females with cubs of the year or yearlings. Other conservation measures in the agreement relate to methods and means of hunting, data acquisition and exchange, and annual meetings.

During the 10-year period from 1988–1989 to 1997–1998 (the recording year being 1 July–30 June), Alaskan and Canadian hunters combined took an average of 58 bears per year (range = 36–90) from this population. The average annual Alaska component for that period was 35 and the range was 21–58. The average annual harvest from the SBS stock was 33 bears in the 1990s and 32 in the 2000s; the combined average annual harvest in the past five years was 54 bears and the Alaska portion of the harvest has been fewer than 20 bears since 2005 (USFWS 2009a). The combined harvest exceeds the MMPA potential biological removal (PBR) for the SBS stock, which was established as 22 bears per year in accordance with the most recent population estimate in 2006 (USFWS 2009a). For this reason, adjustments in the allowable harvest level may become necessary (Schliebe et al. 2006).

3.3 HUMAN RESOURCES

3.3.1 Socioeconomics

The socioeconomic geographic scope for the Project area is defined as the NSB, based on the potential project contributions to NSB revenue and regional employment. The area from Nuiqsut east to Kaktovik and seaward of the barrier islands south to the Brooks Range receives additional focus as the area containing the nearest communities to the Project area, and thus most likely subject to potential socioeconomic effects from the proposed action.

The following discussion will focus on population, employment, income, local economy, and pubic revenues and expenditures. All are vital and integrated components of the North Slope socioeconomic system. There is an analytical distinction between the "subsistence" and the other characteristics that form the basic description of a "monetary" economy, although the two are interdependent and integral components of the economic system practiced by a majority of the NSB's population. This distinction is mostly an artificial and legal distinction of convenience. The Alaska National Interest Lands Conservation Act (ANILCA) legally defines Alaska Native subsistence rights (on federal lands) and mandates that any action affecting federal lands or requiring federal actions (such as permits) must describe and analyze the potential effects of that proposed action on subsistence uses. This "ANILCA Determination" requires formal hearings in the potentially affected communities and is generally incorporated into any National Environmental Policy Act (NEPA) process required for the Project.

In this chapter, subsistence will be discussed separately from other (more demographic and econometric) socioeconomic 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, especially given the increased importance of the evaluation of Environmental Justice issues in recent years.

3.3.1.1 Community Profiles

The NSB encompasses the entire northern coast of Alaska and is about 89,000 square miles (14,000 square kilometers) or 15 percent of the state. The NSB was organized in 1972, adopted a home rule charter in 1974, and includes eight villages. These villages are Anaktuvuk Pass, Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright. The NSB also contains the industrial enclave of Prudhoe Bay/Deadhorse and other oil fields. These industrial communities are employment-focused entities of mostly transient workers from outside of the NSB. The predominantly Iñupiat residents of the NSB have historically relied on subsistence activities. A major motivation for the formation of the NSB was to provide services and infrastructure to the resident Iñupiat population, protect the renewable wild resources upon which they remain dependent, obtain a measure of local control of regional economic and resource development, and potentially provide employment opportunities to local residents. That is, Iñupiat of the North Slope sought a way to capture some of the benefits resulting from the development of oil and gas for themselves, as a collectivity. The primary mechanism to achieve these goals was the formation of a political entity with sufficient authority and means to regulate and tax the emerging regional petroleum and other resource development industries (at that time confined for the most part to Prudhoe Bay). This was far from a simple and non-contentious process, and ultimately the courts and the Alaska State Legislature were required to settle the disputes in determining the property taxing authority of the NSB.

Point Thomson is located within the NSB, approximately 60 miles (97 kilometers) west of the community of Kaktovik, 100 miles (161 kilometers) east of the community of Nuiqsut, and 190 miles northeast of the community of Anaktuvuk Pass. The North Slope oil field support center of Deadhorse is located 50 miles (64.4 kilometers) west of Point Thomson.

Kaktovik

History

Until the late 19th century, Barter Island was a major trade center for the Iñupiat and was especially important as a bartering place for Iñupiat from Alaska and Inuit from Canada. In 1923, Tom Gordon, a Scottish whaler and trader, along with Andrew and Susie Akootchook established a trading post at Barter Island that provided a location for resident trappers to trade furs and obtain supplies. With the introduction of reindeer to the area in the 1920s, the settlement became the focus of more sustained economic activity. In the late 1930s reindeer herding ended and fox fur prices crashed, leading to difficult economic times. After World War II, the military selected Barter Island as the location for the first Distant Early Warning (DEW) Line System. The availability of military-related jobs and the opening of a school attracted more people to settle permanently in Kaktovik in the 1950s. The City of Kaktovik was incorporated as a second class city in 1971.

Cash Economy

Economic opportunities in Kaktovik are limited because of the community's isolation (the DEW Line System is now mostly automated, and the Kaktovik station usually only has two civilian contractors in residence). Most employment is for the provision of services, either for the NSB or the City of Kaktovik. The school district provides substantial employment, but most teachers are non-Iñupiat hired from other parts of Alaska or from outside Alaska. Part-time seasonal jobs, such as construction projects, also provide employment for local residents, but also employ transient non-Iñupiat contractors as well. The Kaktovik Inupiat Corporation (KIC) also employs a number of individuals and is involved in local business. Tourism has begun to develop on a small scale as a result of Kaktovik's proximity to the Refuge.

Public Services and Facilities

The NSB provides all utilities in Kaktovik. Water is derived from a surface source and is treated and stored in a 680,000-gallon water tank. A newly constructed piped water and sewer system provides flush toilets, showers, and plumbing for most residences. Homes not connected to the water/sewer system use holding tanks for water and sewage that are pumped and hauled regularly. The NSB provides electricity and subsidizes diesel fuel for the community. The Harold Kaveolook School (pre-school through grade 12, and adult education) is an important focus of the community. Health care is provided by health aides, visiting physicians and other specialists at the Tom Gordon Health Clinic. Emergency services including a fire station housing an ambulance, an engine and a tanker, are provided by both volunteers and NSB professionals.

Transportation

Air travel provides the only year-round access. The Barter Island Airport is owned by the U.S. Air Force (USAF) and operated by the NSB. The USAF plans to transfer this airstrip to the NSB or Kaktovik in the near future, and the State of Alaska is planning to construct a new airstrip in a more suitable location (the current airstrip is low and subject to fog and flooding). The Proposed Airport Improvement Project for Barter Island is currently being evaluated. Marine and land transportation provides seasonal access, through barges and small boats in the summer and snowmachines in the winter.

Nuiqsut

History

The Colville River Delta has traditionally been a gathering and trading place for the Iñupiat (identified with the Traditional Land Use Inventory [TLUI] site of Niglik in particular) and has always offered good hunting and fishing. Seasonally inhabited sites such as Itkillikpaat, Tiragruak, and Kayuktisiluk were regularly used until the late 1940s, at which time the Iñupiat population consolidated in coastal communities such as Barrow and Point Hope due to the presence of schools and potential employment. Nuiqsut was one of three Iñupiat villages in the North Slope region recognized as traditional Native communities by the Alaska Native Claims Settlement Act (ANCSA), even though at the time of the passage of ANSCA there was no permanent population living at those locations.

The village was resettled in 1973 by 27 families from Barrow, who lived in tents while a school, housing, and other facilities were constructed by federal agencies (and local labor) in the summers of 1973 and 1974. Goods and other supplies were hauled from Barrow by tractor and snowmachine. The first airstrip was made by predominantly local labor on mostly level ground, near the river channel chosen for the village site. The old airstrip is still quite evident, and the tent locations of 1973 and 1974 are remembered on special anniversaries with reenactments and other celebrations of the resettlement effort.

Today, Nuiqsut is experiencing rapid social and economic change with a hotel, a large store for groceries and sundries, a water and sewer system, offices for the Village Corporation and the City of Nuiqsut, a community center, a modern and fully equipped school, a fire station with several fire trucks and an ambulance, and the full range of infrastructure and services available and taken for granted in most modern American communities. Oil development has expanded from Prudhoe Bay towards Nuiqsut and, with the production at the Alpine oil field adjacent to the community (located 7 miles northwest of Nuiqsut) and the continuing development of oil in the NPR-A, surrounds Nuiqsut for the most part. The City of Nuiqsut was incorporated in 1975.

Cash Economy

The NSB government and school district, the City of Nuiqsut, and the Kuukpik Corporation (the Nuiqsut village Native Corporation) provide most of the year-round employment in the village.

Part-time seasonal jobs, such as construction projects, also provide employment for local residents, but also employ transient non- Iñupiat contractors as well. Trapping and craft-making provide some income. The Alpine development is located partially on Native-owned land, so shareholders of the Kuukpik Corporation and the Arctic Slope Regional Corporation (ASRC) (the regional for-profit corporation) have received annual dividends based on its production, which began in 2000.

Public Services and Facilities

The NSB provides all utilities in Nuiqsut. Water is derived from a lake and is treated. In 2003, all but one of the Nuiqsut households had running water. About 88 percent of the households with running water have it piped to the house. About 9 in 10 Nuiqsut households have flush toilets. Homes not connected to the water and sewer system use holding tanks for water and sewage that are pumped and hauled regularly. Electricity is provided by the NSB. The Alpine oil field will soon be providing piped natural gas to Nuiqsut, which will substantially decrease the cost of running the electric generator and heating homes. The power plant, some other public buildings, and a few residences (primarily Elders) have already been converted to natural gas. There is one school (pre-school through high school) located in the community. Health care is provided by the North Slope Health Clinic. Emergency service is provided by 911 telephone service, volunteers, and a health aide.

Transportation

Air travel provides the only year-round access. The 4,343-foot-long by 90-foot-wide gravel airstrip is owned and operated by the NSB. Marine and land transportation provides seasonal access, through barges and small boats in the summer and snowmachines in the winter.

Anaktuvuk Pass

The residents of Anaktuvuk Pass are known as the descendents of the Nunamiut. The community is the only remaining settlement of the inland northern Inupiat. Anaktuvuk Pass is situated at approximately 2,200 feet in elevation in the Endicott Mountains of the Brooks Range, within the region that has become Gates of the Arctic National Park and Preserve. The community is located about 250 miles southeast of Barrow.

History

The Nunamiut people have lived in this region for at least 4,000 years and in the immediate vicinity of Anaktuvuk Pass for over 500 years. Much of the community left the Brooks Range in the 1920s due to a sharp decline in caribou populations and the influx of cultural changes from western settlers. The residents scattered along the Beaufort Sea coast. In the 1930s, some Nunamiuts returned to the mountains, establishing temporary base camps. By 1949, Anaktuvuk Pass had become a permanent camp, and had sporadic service from air taxis. The first post office was established in the community in 1951. By 1959, the village was incorporated as a fourth-class city. In 1971, the community achieved status as a second-class city. Nunamiut Inupiat Corporation is the local village corporation. The Village of Anaktuvuk Pass is a federally recognized tribe, and is governed by the Nagsragmiut Tribal Council

Cash Economy

Economic and employment opportunities are very limited in Anaktuvuk Pass. The NSB and the school district (Nunamiut School) provide most local jobs. City government and the village corporation are also important employers in the community (Shepro et al. 2003).

There are high levels of unemployment and underemployment in the community. The community population is increasing, but the number of jobs is not increasing at the same rate (Shepro, Maas et al. 2003). Household and per capita incomes for Anaktuvuk Pass were estimated by the Borough (Shepro, Maas et al. 2003) to be about one third less than similar estimates from the 2000 U.S. Census. Approximately 20 percent of households receive income from sales of crafts, including caribou skin masks, jewelry, and clothing items (Shepro et al. 2003).

Public Services and Facilities

The NSB provides all utilities in Anaktuvuk Pass. Water is provided by a community well and in 2003, an estimated 90 percent of households had running water and flush toilets (Shepro et al. 2003). The NSB Power and Light System operates the local electric utility. Electricity is generated using diesel fuel and transmitted to housing via above-ground transmission lines (Grinage 2004). There is one school (pre-school through high school) located in the community. Health care is provided by the North Slope Health Clinic. Other community facilities include the city hall/recreation building, senior/teen center, police station, fire station equipped with fire engines and an ambulance, and the Simon Paneak Memorial Museum.

Transportation

Air travel provides the only year-round access. The gravel airstrip is owned and operated by the NSB.

Industry Enclaves

Industry enclaves are not communities in the sense that Kaktovik, Nuiqsut, and Anaktuvuk Pass are. They are organized and function strictly for the economic production of oil and gas. As such, they do not have any permanent population – nearly everyone is a non-resident transient who is only on the North Slope in an employment-related capacity. These enclaves have little or no public infrastructure – all facilities are in some way related to servicing the private economic entities operating on the North Slope. The NSB has a presence within the industrial enclaves, through regulatory oversight and zoning/permitting authority, as well as providing services for the Deadhorse/Prudhoe Bay complex.

The central industrial enclave is located at Prudhoe Bay- Deadhorse area. Others, such a Kuparuk, Endicott, and Milne Point have camp facilities but are connected to Deadhorse by a controlled access road system. Remote enclaves with camps include Northstar, Alpine, Badami, and Ooogruk, which are accessed only by air and or boat.

3.3.1.2 Population, Employment, and Income

The population, employment, and income characteristics of the state and communities on the North Slope are affected by resource development projects such as the Project. In addition to the potential beneficial effects of direct project employment, indirect effects occur through sales of services and materials to the petroleum industry, increased dividends to shareholders from ANCSA Corporation industry-related business, and from North Slope services and capital projects funded by revenues derived from oil and gas development projects. ASRC, KIC, and the Kuukpik Corporation all have subsidiaries that provide oil and gas support services. These provide economic returns to the corporations and also at least potential employment opportunities to NSB residents.

Population

State of Alaska

The 2008 Alaska population estimate is 686,300, which is an increase of approximately 1 percent from the 2000 U.S. Census Bureau (USCB) estimate of approximately 627,000 (http://factfinder.census.gov). The 2008 USCB estimate is about 6,500 more than the estimate prepared by the Alaska Department of Labor (ADOL), which estimated a 2008 statewide population of 679,700 (http://laborstats.alaska.gov). Over the past decade, ADOL estimates of annual population growth have ranged from 0.2–3 percent. Figure 3-29 presents population data for the state since 1950.

North Slope Borough

The estimated 2008 NSB population is 6,706, a decrease of 1.2 percent from the 2000 census estimate of 7,385 (ADOL 2008). Approximately 68 percent of the NSB population is Alaska Native (USCB 2008). Most of the non-Iñupiat population resides in Barrow, while the other villages have populations that are predominately Iñupiat. Over the past decade, ADOL estimates of annual NSB population growth have ranged from -1.2 to +5 percent.

Kaktovik

Kaktovik is located on Barter Island (and is sometimes referred to as Barter Island) and was known as a trading center for people both to the west and the east (Barrow area to the MacKenzie Delta area). It was also a well used seasonal subsistence location, with access to a wide variety of resources (fish, caribou, sea mammals, and sheep in the nearby mountains).

Once Tom Gordon established a trading post at Barter Island in 1923, a permanent settlement began to coalesce. The local population began to significantly increase in 1947, when the USAF built an air strip, on top of most of the preexisting village, and moving the existing population to a site about a mile to the west. The Naval Oil Exploration Program provided some employment opportunities for local residents during that time.

In 1951, the entire area around Kaktovik was made a military reservation. In 1953 the Native community again needed to relocate, this time to accommodate the construction of a DEW Line Station, the first in what would become an extensive system across northern Alaska and Canada. The village remained at that location until 1964 when the USAF relocated the Native community for a third time, so that the DEW Line could expand (Nielson 1977).

The DEW Line site provided employment possibilities for local Iñupiat and the establishment of a school in the early 1950s further facilitated the population consolidation in Kaktovik of people from the surrounding coastal areas. Kaktovik's estimated 2008 population is 272 people (ADOL 2008). Approximately 75 percent of the population is Alaska Native. The 2000 USCB population estimate was 293 people. Figure 3-30 presents current and historic population data for Kaktovik.

Nuiqsut

Just before the establishment of Nuiqsut in 1973, only one or two families still maintained residence in the general area. When Nuiqsut was established in 1973, less than a dozen people lived there (the Allens and the Woods families) in different locales. A number of people chose to settle there, and relocated from Barrow and the other villages. After the several waves of settlers had arrived at the new community site on the Nigliq Channel, 27 families and approximately 175 people lived there (Pedersen 1995). Since then, the population has increased, to 433 people in 2000 (USCB 2008) and estimated at 383 people in 2008 (ADOL 2008).

As with many rural Alaska communities, residence in Nuiqsut can be a flexible concept that is poorly represented by the "snapshot" presence or absence of individuals on the given day of a formal census. Thus the population difference between 2000 and 2008 may or may not be significant. The USCB and ADOL use different methodologies, and may have taken their counts at different times of the year. Approximately 88 percent of the population is Alaska Native. Figure 3-30 presents current and historic population data for Nuiqsut.

Anaktuvuk Pass

The Anaktuvuk Pass population has increased from a 1950 census estimate of 66 residents to 346 residents in 2003 (Shepro et al. 2003). The growth pattern has been steady, with some plateaus and minor declines. Anaktuvuk Pass has a young population; average ages in Anaktuvuk Pass are less than in the state or nation. There is a high ratio of dependents to wage earners (Shepro et al. 2003).

Industrial Enclaves

Nearly 90 percent of Alaska's oil industry employment is concentrated in three areas: Anchorage, and the North Slope and Kenai Peninsula boroughs. Most of the oil is produced on the North Slope, and Anchorage is the business headquarters for most of the producers and industry support companies. The NSB is home for the majority of the oil and oil-related industries jobs in Alaska, 7,540 (57 percent) out of 13,101 statewide in 2007 (Fried 2008). These jobs are located in Deadhorse, Prudhoe Bay, Kuparuk, Nuiqsut, Coldfoot, and Umiat.

Employment and Income

Alaska's economy has eight basic sectors: the federal government and the petroleum sectors, are the two largest job producers for Alaskans, with seafood, tourism, mining, timber, air cargo, and federal retirement benefits and investment income providing the rest (Goldsmith 2008). The number of Alaskans employed in these basic sectors is only a small fraction of the total jobs they generate. For example, in the petroleum sector, only a small number (about

5,000) of Alaskans work directly in producing oil and gas, but the petroleum sector itself supports more than 100,000 jobs (Goldsmith 2008).

In Alaska as much as a third of the state's economic activity is somehow tied to oil, giving it a prominent place in the discussion of employment and income. Oil industry employment in June, 2008 stood at 12,600 jobs, representing just 4 percent of all wage and salary employment in Alaska, based on 2007 average annual employment numbers (Fried 2008). Although it is a small slice of the employment pie, oil revenue funds made up 88 percent of the Alaska general fund's unrestricted revenue.

North Slope Borough

The ADOL unemployment estimate in 2008 was 4.3 percent, compared with a statewide unemployment rate of 6.7 percent (http://www.labor.state.ak.us/ research/emp_ue/nosllf.htm) (ADOL 1999). Between 1975 and 2008, state estimates of unemployment have ranged from a low of 3.5 percent to a high of 10.1 percent (ADOL 1999).

This differs with NSB estimates of unemployment, which are generally much higher than state estimates. For example, in 1993, the state estimated unemployment in the NSB at 11.9 percent, while the NSB estimated unemployment at 22.9 percent for the same year (NSB 1995). The discrepancies in unemployment figures likely derive from different definitions of unemployment. The NSB includes discouraged workers who are involuntarily unemployed and are no longer seeking work, whereas the federal definition does not. The differences become even larger when, instead of looking at employment/unemployment in terms of a "snapshot" at a given point in time, the annual pattern of employment is examined. Underemployment is common on the North Slope, either due to working less than 40 hours a week or working only seasonally (even though such jobs may well require overtime for the period worked) (Shepro et al. 2003).

Most, if not all, oil industry jobs are held by people residing outside the NSB in other parts of Alaska or outside Alaska (MMS 2008). In the past, only a small percentage of North Slope oil-industry workers were Alaska Native (USDOI 1998; MMS 1992); however, increasing workforce diversity is an industry goal and companies like Kakivik Asset Management are meeting or exceeding 20 percent Alaska Native hire (Coldby 2007). However, most NSB employment is indirectly related to oil industry activities, through taxation revenue. NSB residents are also employed indirectly in support and service functions contracted to ANCSA corporations by the oil industry.

The NSB is the most important employer in these communities. The NSB, including the government and school district, employed approximately 51 percent of all working NSB residents in 2003, down from 62 percent in 1994 (NSB 1995; Shepro et al. 2003). Most of the other residential workforce is employed by the regional or village ANCSA corporations (or subsidiaries and joint ventures), and local community governments.

The average household income in the NSB increased from $44,462 in 1993 to $55,793 in 2003 and per capita income increased from $12,874 in 1993 to $24,932 in 2003 (Shepro et al. 2003). The poverty level in all NSB communities, except for Barrow, increased during this period as well. In 1998, 76 households qualified as poverty level and very low income (1.25 percent of the poverty level as defined by the USCB) and in 2003 this number increased to 100 households out of 480 reporting households. (In 1998 the poverty level was defined as annual income of under $16,530 for a household of two adults and two children; in 2003 it was $18,660)

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. Point Thomson related work could offset some of this projected decline for strategically placed service providers, especially in the drilling and construction phases of the Project.

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 community improvement program, employing a large number of residents through selling bonds. As these projects are completed and the bonds retired, more of the NSB's budget will be shifted to operations. Community improvement program-related employment is projected to decline significantly. The Project will again counter at least part of this anticipated decline in NSB revenue, through the construction of new infrastructure, but is not expected to directly contribute to a reversal of this trend. Point Thomson can be expected to contribute significantly to the future construction of a gas pipeline and the commercial utilization of North Slope gas, and its associated economic benefits.

Nuiqsut

The NSB conducts a census of borough communities every five years. The most recent census was conducted in 2003 and information has not been updated since this census. The most recent estimate of Nuiqsut labor force participation was 169 people in the labor force out of the total population of 383 people (Shepro et al. 2003). According to the NSB, unemployment borough-wide was 17 percent. Members of the workforce identified unemployment and underemployment as persistent and serious problems in their communities (Shepro et al. 2003).

Many jobs are seasonal, primarily those in construction or with oil field service companies. In 2003, approximately 46 percent of regularly employed Nuiqsut residents worked for the NSB, compared with approximately 63 percent in 1993 (Shepro et al. 2003; NSB 1995). The village corporation, Kuukpik Corporation, and its subsidiaries employed approximately 31 percent of the workforce (Shepro et al. 2003). The city had five employees in 2003, compared with three in 1993, and the state had one compared with zero in 1993. All other employers accounted for approximately 23 percent of total employment. Craft sales also contributed to the economy, however are not accounted for in employment numbers. Approximately 23 percent of Nuiqsut households participated in craft sales in 2003 (Shepro et al. 2003).

The average household income in Nuiqsut has increased from $39,200 in 1993 to $59,900 in 2003. The average income for Iñupiat households was $52,000, whereas the average income for non-Iñupiat households was $77,500 (NSB 1995; Shepro et al. 2003). In 2008 the federal census estimated average household income at $68,589 (http://quickfacts.census.gov/qfd/states/02000.html).

According to the NSB, approximately 18 percent of households in Nuiqsut were below the poverty threshold (Shepro et al. 2003), whereas the federal census in 2000 reported 9.9 percent of families below the poverty threshold.

Non-Iñupiat households in Nuiqsut are generally smaller than Iñupiat households, and consist primarily of salaried schoolteachers with typically one or two adults and no children. Iñupiat households are generally composed 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).

Living expenses in Nuiqsut are quite high compared to both state 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, and are also very important traditionally and culturally. Participation by Iñupiat residents of Nuiqsut was 95 percent, and 81 percent of households participated in the local subsistence economy (Shepro et al. 2003). Participation estimates have remained consistent with estimates from 1993 and 1997 (NSB 1995; Brower and Opie 1997).

Cash expenditures for subsistence activities can be quite high. Of the 50 households that responded during the 2003 survey, each household, on average, spent approximately $6,700 on subsistence expenditures. In total, these 50 households spent $335,000 on subsistence, which is approximately 20 percent of the gross incomes of these families (Shepro et al. 2003).

Kaktovik

The most recent unemployment rate reported by the NSB for Kaktovik was 9.4 percent (Shepro et al. 2003). Of the 286 residents of Kaktovik, about 84 participate in the labor force (Shepro et al. 2003).

Many jobs are seasonal, primarily those in construction or with oil field service companies. Approximately 57 percent of regularly employed Kaktovik residents worked for the NSB in 2003, which is a 10 percent decrease from 1993 (Shepro et al. 2003; NSB 1995). The village corporation, Kaktovik Iñupiat Corporation, and ASRC combined employed approximately 27 percent of the workforce, compared with 16 percent in 1993. In 2003, the city had three employees, and the federal government one employee. All other employers accounted for approximately 16 percent of total employment. An unknown number of Kaktovik residents and at least one Nuiqsut resident have been working on the Project in 2009 as bear guards, marine mammal observers and other project-related activities. Nanuq Incorporated (a Kuukpik Corporation subsidiary) employed an unknown number of North Slope residents on the 2009 ice road construction project, and Marsh Creek LLC (partly owned by KIC) has also likely employed a number of North Slope residents on project-related business.

Average household income in Kaktovik was $59,300 ($17,900 per capita) in 2003. Iñupiat versus non-Iñupiat household incomes were not reported separately. However, in 1993, non-Iñupiat household income reported was $71,874 ($43,230 per capita), while average Iñupiat household income is $30,984 ($9,832 per capita) (NSB 1995). Approximately 38 percent (29 of 77) of surveyed Kaktovik households reported incomes below the poverty level (Shepro et al. 2003). Income from craft sales contributes to the local economy, being roughly double the average of craft income in Nuiqsut.

Non-Iñupiat households in Kaktovik are generally smaller than Iñupiat households. Non-Iñupiat households are generally salaried schoolteachers without children. Iñupiat households are generally composed of more members and fewer wage earners.

As in Nuiqsut, living expenses in Kaktovik are quite high compared to both 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).

Kaktovik families rely heavily on subsistence harvests (Brower et al. 2000). Approximately 93 percent of Iñupiat households in Kaktovik participate in the subsistence economy, and 80 percent of non-Iñupiat households use subsistence resources (Shepro et al. 2003). The percentage of households who reported "heavily reliant" on subsistence resources (those who consumed all or nearly all of their food from local resources) increased from 35 percent in 1998 to approximately 41 percent in 2003 (Shepro et al. 2003; NSB 1995). The average household spent $4,788 on subsistence expenditures, and the community spent about 10 percent of their gross income on subsistence.

3.3.1.3 Public Revenues and Expenditures

The NSB relies primarily on property tax receipts to fund its operations and pay interest and principal on its bonds. The NSB collected 70 percent or $200 million of its revenue from property tax during 2006/2007. Nearly all property tax (approximately 98 percent) comes from assessments on the oil industry and state and federal revenue-sharing programs contribute most of the remaining NSB budget funds. About 60 percent of the NSB budget is for operations, and 40 percent is for debt service, primarily on bonds sold to fund the community improvement program.

NSB oil and gas property tax revenues have exceeded $180 million annually since 1983. Adjusted for inflation, 1985 was the peak year at $240 million (Northern Economics Inc. 2006). The NSB total general fund actual revenue was $279 million for 2004/2005, $265 million for 2005-2006, $289 million for 2006/2007 and a projected $319 million for 2008/2009 (ADNR 2009).

Because of declining tax revenues and increasing operational expenses, the NSB is actively seeking to reduce its operating budget, and has become more conservative in the number of bonds sold to finance capital improvements. Capital improvement project budgets peaked between 1981 and 1985 at $302 million in 1983 (NSB 1995). Anything that the borough builds must be maintained under the legal operational tax cap of $4.78 million (USDOI 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 as a result of a stagnant or declining property tax base.

The communities of Kaktovik and Nuiqsut rely on the NSB for most public services and for most full-time jobs. As such there are limited local sources of funds. A significant source of income in Nuiqsut is dividends the Kuukpik Corporation distributes based on the royalties obtained from the Alpine oil developed on corporation land. Another source of income recently in Nuiqsut has been NPR-A Impact Mitigation Grant funds, made available through the State of Alaska Department of Commerce. In Kaktovik a significant source of city funds comes from bingo and pull tabs, which is essentially a locally-generated tax.

3.3.2 Cultural Resources

Cultural resource sites on Alaska’s North Slope contain non-renewable data about human history before 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 about human prehistory or history. These resources can be located in uplands, the intertidal zone, and/or under water.

3.3.2.1 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) (CFR 2004). A site must be more than 50 years old to be considered a “historic property” unless it has exceptional national, state, or local significance. Certain Alaska Native sacred sites may also be significant (Executive Order) (FR13007 1996), and certain traditional cultural properties also may be eligible for the National Register (36 CFR 60.4) (FR 1981). The State of Alaska Historic Preservation Act and the NSB also stipulate protection of area cultural resources.

The Alaska Office of History and Archaeology (OHA) and the NSB Inupiat History, Language, and Culture (IHLC) Division are the primary repositories of archaeological and historic land use data for the North Slope. The OHA maintains the Alaska Heritage Resources Survey (AHRS), a statewide listing of archaeological site data. The NSB’s 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, quarries, trails, and landmarks. The 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 be found on area shorelines. The U.S. Department of the Interior's MMS maintains a historic shipwreck database including more than 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 describe current management schemes for shipwrecks.

3.3.2.2 North Alaska Prehistory

Archaeological finds in the Alaska Arctic indicate occupation and use of the area for well in excess of 10,000 years. 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 3-31). The Mesa Site is the oldest and best-dated (Kunz and Reanier 1994), followed by the Putu (Alexander 1987) and Bedwell sites (Alexander 1974; Reanier 1995), where ancient lanceolate projectile points were found.

Paleoarctic sites from northern Alaska include the Gallagher Flint Station (Dixon 1972; Bowers 1983; Ferguson 1995), a site that also yielded Northern Archaic and Arctic Small Tool Tradition (ASTT) materials, and the Lisburne Site (Bowers 1982, 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."

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

The 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 ASTT are now recognized. The North Slope ASTT sites include Putuliguyuk 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 key to modern Inupiat cultural survival. In the Historic Period, 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, along with the effects of oil development. Cooperative resource harvesting and sharing persist in the 21st century among the Inupiat and continue to bind people to their homeland on the North Slope.

3.3.2.3 Point Thomson Cultural Resources

Scores of commercial whalers passed by Point Thomson 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 recorded 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 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, about the same time that inland caribou populations crashed. In addition, influenza 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-20th 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 and 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 Panningona family ran their trapline from Flaxman Island as far as Point Gordon (NSB 1980) and also hunted caribou in this area. Located at Point Thomson were three interconnected sod houses belonging to the Pausanna, Utuayuk, and Kuniochiak families. Sara Kunaknana's family wintered in the same area during the 1920s.

Evidence of Inupiat heritage in the 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…"*

Numerous site-specific and general archaeological surveys focused on identifying eligible cultural resources in the Point Thomson area, beginning with Campbell (n.d.) in 1974. Surveys conducted for oil and gas exploration and development (Bacon 1982a, 1982b, 1983, 1985; Dames & Moore and Lobdell 1986; Lobdell 1980, 1992a, 1992b, 1992c, 1997a, 1997b, 1998, 2000) have documented 21 AHRS and TLUI sites in the Project area, two of which are on Flaxman Island (Table 3-32). In general terms, the low-lying nature of the Project area's landscape, specifically Point Thomson area shorelines and the expansive areas of wet tundra, reduces the archaeological sensitivity of the Project area. A survey conducted for a planned road construction project west of Point Thomson updated the condition of a number of sites in the Project area (AHRS site references XFI-0001, XFI-0004, and XFI-0005) and documented ongoing erosion impacts (Reanier 2007). An August 2009 field survey in support of a forthcoming Cultural Resource Management Plan for the Project area mapped the known Project area sites and identified a new prehistoric site on an inland pingo.

The observation 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) has been 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 SRRS 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 gravesite XFI-007 on Flaxman Island (Lobdell 1997a). Although geological processes, including coastal erosion and sea-level rise, have likely altered or destroyed ancient shoreline sites that may once have been located along the Beaufort Sea coast (Darigo et al. 2007), 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 3-32: 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 SRRS (POW-3)
XFI-00022	TLUIXFI002	Bullen Point SRRS (POW-3)
XFI-00023	TLUIXFI002	Bullen Point SRRS (POW-3)
XFI-00024	TLUIXFI002	Bullen Point SRRS (POW-3)
XFI-00025	TLUIXFI002	Bullen Point SRRS (POW-3)
XFI-00026	TLUIXFI002	Bullen Point SRRS (POW-3)
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]
XFI-00031		A2 Pingo
XFI-00032		Badami River Flake Scatter
XFI-00033		Brownlow Cemetery
XFI-00034		Brownlow Southern Grave
XFI-00035		Brownlow Prehistoric Surface Artifacts

Notes:
* site destroyed
AHRS = Alaska Heritage Resources Survey
DEW = Distant Early Warning
SRRS = Short-range Radar Station
TLUI = Traditional Land Use Inventory

3.3.3 Subsistence and Traditional Land Use Patterns

"Subsistence" must be discussed as a standalone topic in this ER (and the subsequent EIS) because of specific provisions in the ANILCA that confer special protections to the customary and traditional uses of renewable wild resources by rural Alaskan residents. Before presenting information describing the patterns of such uses that may be potentially affected by the proposed action, this section will introduce the requirements of ANILCA, which will be further elaborated in Chapter 4, Environmental Consequences.

3.3.3.1 ANILCA and the Regulation of Subsistence Activities in Alaska

The term *subsistence* has different definitions and meanings (Davidson 1974; Arnold 1978; Lewis 1978; Lonner 1980; Kelso 1981, 1982; Case 1984; Berger 1985; Caulfield and Brelsford 1991; Kancewick and Smith 1991; Naiman 1996; Loescher 1997). All definitions of subsistence emerge from a complicated legislative and social history. The current federal and state debate over the constitutional status of subsistence priorities notwithstanding, the ANILCA provides the operational basis for definition of the term subsistence in this document. Although the proposed action will take place on state land, it requires a large number of permits from federal agencies and so is defined as an action affecting federal lands. ANILCA has been ruled to apply only to onshore federal lands and waters in Alaska, and not to offshore waters, but other federal laws discussed below apply in off shore areas. The analytical framework federal law constructs is the basis of all current documentation of Alaskan subsistence activity, both by the state and the federal governments. The dispute between the State of Alaska and the federal government is generally not about what "subsistence activities" are, but rather who qualifies as a "subsistence user" in terms of a priority for consumptive use of subsistence resources (and to some extent, which resources are "subsistence stocks"). For the state, all Alaskan residents are potentially qualified subsistence users, whereas for the federal government only rural Alaskan residents are potentially qualified subsistence users. Areas of Alaska classified as "non-rural" are Anchorage, Fairbanks Northstar Borough, the Juneau area, Valdez, the Ketchikan area, the Wasilla area, and the Kenai Peninsula area.

In addition to ANILCA, other legislative acts and regulatory actions relevant for the understanding of subsistence management issues on federal lands include the Federal Subsistence Management Regulations (36 CFR 242 or 50 CFR 100, summarized and available as USDOI, USFWS 1999), the Federal Advisory Committee Act (FACA), and the Federal Advisory Committee Management Regulations (41 CFR 101-6). The MMPA and the ESA are also pertinent, addressing the harvest of marine mammals, currently restricted to subsistence use by coastal Natives.

ANILCA explicitly recognizes that for rural Alaskans (Native and non-Native) "subsistence" subsumes a complex set of behaviors and values that extend far beyond the harvest and consumption of wild resources, although it is formally defined primarily in those terms. The current regulations define "subsistence use" as "… the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools of transportation; for the making and selling of handicraft articles out of nonedible by-products of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade" (USDOI, Federal Subsistence Board [FSB] 1999). For some resources in certain areas the FSB has determined that all rural Alaskan residents are qualified subsistence users. For other resources, the FSB has made more restrictive "customary and traditional" determinations of eligibility. To show customary and traditional use, a community or area is evaluated in terms of the time, depth, and consistency of its use; seasonal repetition over many years; efficiency in terms of effort and cost; consistency of harvest or use of fish and wildlife in proximity to the community or area; historic or traditional means of handling, preparing, preserving, and storing fish and wildlife that have been used by past generations; the intergenerational transmission of hunting and fishing skills, values, and knowledge; sharing and distribution of the harvest; dependency upon a wide variety of fish and wildlife resources available in an area; and the provision of substantial cultural, economic, social, and nutritional elements to the community or area.

3.3.3.2 General Overview of Subsistence in Alaska

"Subsistence" as a label incorporates a complex of behaviors and values which extends far beyond the harvesting and consumption of wild resources. Harvest and consumption are merely the most visible aspects of such a system, and the most logical entry point for examining a social system with a subsistence ideology. The fundamental values of such societies are expressed in the *idiom* of subsistence, so that kinship, sharing, and subsistence resource use behaviors (e.g., preparation, harvest, processing, consumption, and celebration) become inseparable (Langdon and Worl 1981; Elanna and Sherrod 1984). Worl (1979) and Nelson (1979) describe subsistence as a central focus of North Slope personal and group cultural identity in addition to its primary economic role. Hopson (1976, 1978) establishes the political and ideological power of subsistence as an organizing concept for the NSB. The NSB currently is the most organized, strongest and best-funded subsistence economy in Alaska. In each region, communities express their unique identities based on their enduring connections between current residents, those who used the areas in the past, and the wild resources of the land. Elder's conferences, spirit camps, and other information exchange and gathering events serve to solidify these cultural connections between generations, and between the people and the land and its resources. This is not to say that all local subsistence economies are the same; however, the general values and central organizing concepts have many common threads.

Many studies have examined the relationship between the subsistence and wage economies and how both subsistence and wage activities are integrated into rural Alaskan socioeconomic systems. (General theoretical or conceptual treatments are available in Wolfe 1983; Wolfe et al. 1984; IAI 1988). Although not always made explicit, it is recognized that all rural communities and rural socioeconomic systems are not the same. One salient variable is the ethnic composition of the community, while another is the diversification of the local economy and the availability of wage employment.

An extensive series of community studies focused on local patterns of wild resource use as a component of the overall economy was conducted during the 1980s, in a wide range of communities throughout Alaska (Sobelman 1985; Reed 1985; Stratton 1989, 1990, 1992;

Galginaitis et al. 1984; IAI 1989). Some of these communities are predominately Alaska Native, others are predominately non-Native, and yet others are more ethnically "mixed". Some have developed wage (or self-employment) economies, others have few such opportunities. Within the NSB both subsistence activities and wage economic opportunities are highly developed, and highly dependent upon each other (Kruse et al, 1981; Kruse 1982, 1991; Harcharek 1995; Shepro and Maas 1999). Those most active in subsistence activities tend to be those who are also very involved in the wage economy. That is, monetary resources are needed to most effectively harvest subsistence resources, both as an individual (e.g., to purchase a boat, snowmachine, four-wheeler, or all-terrain vehicle [ATV], fuel, guns, and ammunition) or as the head of a collective crew (for whaling, for instance). There is evidence that Native subsistence users as a group display a different pattern of use than do non-Natives (different species of resources, harvest and consumption of larger quantities, more widespread sharing and distribution of resources).

Rural Alaskans harvest over 40 million pounds of wild foodstuffs every year (Wolfe 1996). The wild food produced through hunting, fishing, and gathering, on average, amounts to just over one pound per person per day. Nobmann (1997) compares harvest data to a type of "food balance sheet." Harvest data describe the amount of wild food available to a certain group of people, and are a rough estimate of what is eaten. Actual consumption varies from what is harvested or brought into the kitchen. However, few wild food consumption studies have been undertaken in Alaska.

Subsistence foods consist of a wide-range of fish and game products that have substantial nutritional benefits. They are generally rich in nutrients, low in fats, and they contain more heart-healthy fats and less harmful fats than many non-Native foods (Nobmann 1997). Subsistence foods also contribute to good health. Social, emotional, spiritual, and cultural benefits are other important aspects of subsistence food harvesting and sharing that contribute to personal and community health.

According to 1990 estimates (Wolfe 1996), the annual wild food harvest in rural Alaska was 375 pounds per person, compared to 22 pounds per person in urban Alaska. Assuming that, on average, 0.2 pounds of wild food contains 44 grams of protein, and 2.94 pounds of wild foods contains 2,400 Kilocalories, the amount of wild food harvested in 1990 represented 243 percent of the rural population's protein requirements, and 35 percent of the population's calorie requirement. In contrast, the food reportedly harvested by urban residents represented 15 percent of their protein requirements, and 2 percent of their calorie requirements. Clearly, wild foods represent a major source of healthy foodstuff in rural Alaska.

3.3.3.3 Overview of Subsistence Activities in the Project Area

As discussed above, "subsistence" encompasses a wide-range of activities, and for some groups and individuals is a shorthand expression for the most central and important aspects of their lives. The most visible and easily documented component of this complex of subsistence activity is the actual harvest of subsistence resources. Broad community discussions of selected aspects of subsistence resource harvest activities are provided below, followed by summary descriptive information for Kaktovik and Nuiqsut (the two communities closest to the Project area) based on the most recent information available.

In general, communities harvest the subsistence resources most available to them, concentrating their efforts along rivers and coastlines and at particularly productive sites. 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. Human factors such as timing constraints (due to employment or other responsibilities), adequate equipment (or the lack of it) to participate, and hunter preference for one resource over another or one sort of subsistence activity over another, are also important components in determining the overall community pattern of subsistence resource harvest and use. Resources that comprise relatively little of the overall total harvested or consumed, and areas that are only infrequently used for subsistence activities can both be important components of the overall pattern (USDOI 1998). For example, waterfowl represent only a small part of the total wild food consumed by the residents of Kaktovik and Nuiqsut, but is only seasonally available and is avidly anticipated in the spring and fall as a fresh change in the diet. Duck and other waterfowl soup is an almost mandatory part of the first course served at *Nalukataq*, and one of the tasks of the crew members of a successful captain is to ensure that he has enough ducks and geese for *Nalukataq*. Similarly, although most subsistence activities are guided by experience and expectations of where these resources are most likely to be found, variability is also part of the pattern. Animals may, for whatever reason, not be encountered in "normal" locations, so that subsistence users must search less intensively used parts of their larger use area – but parts that are relatively well known to them as locations where animals have been found and harvest has been successful in the past.

Two broad subsistence-resource niches occur on the North Slope, but these are more useful as conceptual or analytical categories than as explanations for community (or individual) subsistence resource patterns:

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

Kaktovik and Nuiqsut both depend on resources from each of these resource constellations, with marine mammals (and especially bowhead whales, due to their size), caribou, and fish as the primary resources harvested. The communities differ in the overall composition of their subsistence harvests; however, Kaktovik, located on Barter Island and with no nearby rivers that are navigable for any great distances, has much more of a maritime orientation (a reliance on marine mammals, but also ocean coastal access to caribou). As discussed in more detail in a later section, 59–68 percent of the community's total subsistence harvest has historically consisted of marine mammals, 17–30 percent of terrestrial mammals, and 8–13 percent of fish. Kaktovik is also located nearer to the mountains than other coastal North Slope communities, and its residents incorporate snowmachine trips to the mountains to harvest Dall sheep, caribou, and fish at named fishing locations on the Hulahula River and other locations. Nuiqsut, located about 12 miles inland on the Colville River, which is navigable for a relatively large distance, has more of an "inland" orientation. The river also provides access to the ocean, however, and Nuiqsut's residents also rely on the harvest of marine mammals. Their overall total subsistence harvest is almost equally divided among marine mammals, terrestrial mammals, and fish – 32, 33, and 34 percent, respectively in 1993, with 1–2 percent for birds, eggs, and vegetation.

The bowhead whale harvest is important in both communities because it provides a unique and powerful cultural basis for sharing and community cooperation, an organizational framework for activities throughout the year, and a significant portion of the total community subsistence harvest in the "typical" year. Bowhead whaling strengthens family and community ties and provides a sense of common heritage and culture in Inupiat society (USDOI 1998). Sharing and community cooperation were essential in the past, and was insurance against hardship or starvation, maximizing the collective 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 than 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.

The Project area encompasses lands traditionally and presently used for subsistence harvest by residents of Nuiqsut and Kaktovik (Figure 3-33 and 3-42). Traditional subsistence land use in the Project 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 Project area. The following sections initially discuss the overall subsistence activities of Nuiqsut and Kaktovik, and then discuss them specifically in relation to the Project area.

Subsistence harvest data for the two communities is somewhat dated in terms of complete community surveys - 1985, 1986, 1992, 1995 for Kaktovik; 1985, 1993, 1995 for Nuiqsut. These surveys are still useful as indicators of overall community subsistence patterns and the sort of variability that can be expected within those overall patterns. When combined with more recent documentation of specific resources (caribou, bowhead whales, and fish) this can be especially pertinent to the analysis of potential effects from the Project. Unfortunately, much of this most recent information remains unpublished and will require personal contacts with staff members of the agencies that have developed it (ADF&G, USFWS, BLM). This effort will continue as this document is updated.

Although the available systematic harvest information for communities using portions of the Project area is about 20 years old, when interpreted within the context of more current qualitative research it is quite useful and applicable for this report. The limitations of this data set impose a focus on the qualitative *patterns* of subsistence use rather than on the quantitative *measurements* of these patterns. That is, the important aspects of these data are not the raw harvest numbers but the harvest, consumption, and land use *patterns* of that the numbers represent. As discussed below, the actual numbers, even for the relatively few years in the past for which they are available, vary considerably from year-to-year due to the fluctuation of natural conditions. Population and regulatory/management changes also result in annual variations in harvest patterns.

Conclusions about community subsistence resource use based on any limited data set should always be tentative and follow the “precautionary approach” of assuming that potential adverse effects are possible if applicable data are ambiguous or absent. The “most representative year” identified by ADF&G is best conceived as a behavioral norm and illustrated by the subsistence cycle diagrams for each community. During any particular year, some variation from this norm can be expected, and time series (and thus statistical) information (time depth) on these variations is lacking. The qualitative testimony of local experts (“local and traditional knowledge”) is the best and most coherent body of information given the available data’s lack of time depth.

The effects of the proposed action on subsistence patterns should be assessed not only in terms of the normative pattern or “most representative year” for each community, but also for the years of the greatest possible variation experienced in that pattern (such as years when no whales are landed, or years when caribou are not locally available, or years when fish runs are weak). Again, local experts and their experiences are the best source for this information. That said, the more detailed discussion of the information available for Kaktovik and Nuiqsut can be summarized by the following:

- “Subsistence activities” comprise perhaps the major sociocultural focus of Inupiaq culture, and as a component of the Inupiaq socioeconomic system is at least as important as the monetary “Western” component (although the two are irrevocably intertwined);
- Subsistence harvests of wild renewable resources represent a substantial part of the food consumed by residents of Kaktovik and Nuiqsut. These communities are among the highest per capita consumers of subsistence resources in Alaska;
- The systematic information available for Kaktovik indicates a major subsistence dependence on marine mammals (68 percent), with significant contributions from land mammals (17 percent) and fish (13 percent).

In years when fewer than three whales are harvested, harvest effort for land mammals and fish increases, and subsistence resources (especially whale) are imported from other communities through sharing networks. One response to the significant availability of caribou to Kaktovik hunters is the regular sharing exchange between Kaktovik and Anaktuvuk Pass. Whale and other marine mammal products, especially seal oil are sent from Kaktovik to Anuktuvuk Pass, and caribou and other land mammal products are sent from Anaktuvuk Pass to Kaktovik. The

Canning River Delta region, close to the Project area, has been a very productive area for caribou hunting, especially in years when caribou are not found closer to Kaktovik, in some years accounting for about a third of the community's total documented caribou harvest.

The Project could potentially affect the Kaktovik harvest of bowhead whale, since the migration route for bowhead whales using Alaskan waters passes close to the Project area and a low probability but catastrophic event could have population level effects on the bowhead whale population. The Project could also affect the Kaktovik harvest of caribou, since the Canning River delta area adjacent to the Project area is a significant caribou use area for Kaktovik hunters.

The systematic harvest information available for Nuiqsut suggests a well-diversified subsistence harvest, almost equally divided among fish (34 percent), land mammals (33 percent), and marine mammals (32 percent). The discussion below supports this as a reasonable description of more recent harvest patterns as well. Fish resources are perhaps more variable than the others.

3.3.3.4 Subsistence Use Patterns for Kaktovik

Much of the information summarized in this section is relatively old, dating to the 1990s or before. It is generally thought to represent current use patterns in Kaktovik fairly well, but will need to be checked and verified with, at a minimum, a series of interviews with local Kaktovik experts. After a very general description of historical land use and subsistence patterns of the "Kaktovik" area in general, the bulk of this section will discuss the contemporary land use and subsistence patterns of the current residents of Kaktovik. This discussion will start with a brief treatment of the normative annual round (what species are used and when they are used), followed by a more quantitative presentation of amounts that are actually harvested ("dependency" and variability of resources), and then a discussion of areas used for subsistence activities, with a focus on the Project area. Much of the information for this last section is derived from IAI (1990b), which combined a synthesis of earlier published (and unpublished) material with a period of fieldwork focused on community land use patterns. This has been supplemented with the limited amount of more current information available and very limited talks with active subsistence hunters in the community. It is anticipated that these contacts will be augmented by either the ER team in the near future or the EIS team some time in 2010.

Historical Land Use and Subsistence Patterns of Kaktovik Residents

Kaktovik (also referred to as Barter Island) is a small community located on Barter Island in the extreme northeast of Alaska, within the boundaries of the Refuge. The 1990 USCB enumerated 224 people, most of whom (189, or 84 percent) were Native. The 200 census enumerated 293 people, of whom 246 or about 84 percent were Native (Alaska Department of Commerce, Community, and Economic Development [DCCED] certified the population at 272 in 2007). Household economies rely upon both wage labor and subsistence activities as vital components of an integrated system. The major employers are the NSB, the City of Kaktovik, and the village Native (ANCSA) corporation. There are also a few private sector jobs and businesses separate from the Native corporations (retail stores, a motel or camp, and air carrier services are examples), but most employment is related to government or Native corporations (IAI 1990b). Subsistence activities in Kaktovik make use of a unique set of resources. Because of its location, Kaktovik hunters have access to terrestrial, riparian, and marine resources, and make substantial use of all three. Fish are important riverine and ocean marine resources. Caribou are the most important terrestrial subsistence resource, but muskox, bear, and sheep are also taken (with the last becoming something the community is especially known for). The bowhead whale is the primary marine mammal subsistence resource, but seals and polar bears are also taken (Jacobson and Wentworth 1982; IAI 1990a). The central importance of subsistence activities, and especially the bowhead whale, for the structural organization and cultural identity of Kaktovik residents will be further developed below.

Before contact with Euroamericans, the site of the present community of Kaktovik was not a permanent Inupiat settlement, but had a long history as the location for seasonal gatherings for trading. Along with the surrounding area and most of the adjoining coastline, it was also used for seasonal subsistence activities of the highly mobile Inupiat people (Nielson 1977; Kisautaq 1981). One story of how the site came to be called “Kaktovik” (or “Qaaktugvik”) also serves as an explanation for why it was not the site for a permanent village. The story relates how the Qagmaliks from the east (Canada) came to trade and decided to live in the area. They later abandoned the area after some had killed the only son of a couple living in the area. The couple found their son's body while seining, and so the place acquired its name from that activity and became “A-Seining-Place” and those “... living in the wrong way had caused it to have no more people” (Kisautaq 1981; Libbey 1983).

In 1923, the Gordon family moved their store to Barter Island from Demarcation Point, where they had lived since 1917 (prior to that time Tom Gordon had worked with Charles Brower in Barrow and other North Slope locations). Apparently this move was made because Tom Gordon's wife had relatives who had taken up residence on Barter Island because of its location in relation to fishing spots and the mountains (Kaveolook 1977; Jacobson and Wentworth 1982). The nascent settlement also was a more viable location for the trading post, which in turn increased the desirability of Barter Island as a place for families to live. People still lived on the land and traveled extensively, but Kaktovik had become much more of a central service center than before (Jacobson and Wentworth 1982; Libbey 1983).

Later in the 1920s reindeer were brought into the Barter Island area. It is reported that reindeer herding combined with hunting kept people out on the land for most of the time, although their residential focus was Barter Island. Reindeer herding was a family business, with each family having a defined herding area. Taakpaq, the famous whaling captain from Barrow (but sometimes referred to as a Kaktovik whaling captain), herded in the area between Beechey Point and Brownlow Point. Richmond Ologak herded from Brownlow Point east to the Sadlerochit River, while the Akootchooks and Tiglooks herded between the Sadlerochit and Jago Rivers. Gallegher Arey and Mickey Gordon herded from the Jago River to Demarcation Bay (Libbey 1983). Reindeer herding in the Kaktovik area ended in the late 1930s or early 1940s. A number of reasons are cited. These included excessive predation by wolves, competition by the increasing wild caribou herd for food, the difficulty of keeping the domestic reindeer herd separate from the wild stock, the slow (or non-existent) development of a market for reindeer meat and other products, and the decreased interest of the Inupiat herdsmen. The involvement of non-Natives in the industry, as government administrators, business managers, and (during certain periods) as herd owners, certainly had a great effect upon Inupiat participation and interest in the industry. An assessment of the relative weights of these factors is hardly possible, since almost all studies of Alaskan reindeer have focused on the Seward Peninsula and seldom mention North Slope operations. The interested reader is referred to Andrews (1939), Grosvenor (1902), Jackson (1904), Koughan (1931), Miller (1935), Olson (1969), Ray (1983), and Stern (1980).

Trapping also supported a dispersed population, although that population tended to focus itself on a supply center where furs were traded for consumer goods of various sorts. In addition to the trading post on Barter Island run by Tom Gordon, other trading posts were operated by Jack Smith at Beechey Point, Henry Chamberlain at Brownlow Point, John Olson at Imaignauraq, Old Man Store at Demarcation Bay, and others. These trading posts tended to change locations (and proprietors) depending on the productivity of the trapping territory surrounding them. The decline of the fur market in the mid-1930s caused many of these trading posts to close, and other traders died (Tom Gordon died in 1938, John Olson in 1942) or simply moved elsewhere. The net result was that, by the 1930s and 1940, there were few trading posts left and people once again dispersed — some to Canada (the Mackenzie River area, where a trading post remained open), Barrow, or other places. A core population remained in the area, maintaining a mobile subsistence lifestyle (Libbey 1983).

In the mid-1940s the U.S. Coast and Geodetic Survey began mapping the Beaufort seacoast, with their main base camp on Tigvariak Island. Several relatives of present-day Kaktovik residents worked on this project and spent time at Tigvariak Island. In 1947, the USAF began construction of the Barter Island airstrip and hanger facility, forcing the relocation of some Kaktovik residents and disturbing a significant prehistoric village site. In 1951, the entire area around Kaktovik was designated a military reserve, and again some Kaktovik residents had to relocate (Nielson 1977; Jacobson and Wentworth 1982). A DEW-line station was constructed there in 1952 and 1953, as a prototype/test facility for the other proposed stations of the system (Denfeld 1994). A Borough of Indian Affairs (BIA) school was opened in Kaktovik in 1951. The combination of the school and the availability of local wage employment supported a population influx. The population stabilized at about 140 people, and remained at about this level until the late 1970s. Then the establishment of the NSB resulted in more local employment opportunities and an increased (and improved) housing supply (Jacobson and Wentworth 1982).

The period of time since the establishment of the NSB has been one of increased economic stability in Kaktovik, in terms of wage employment, and a modification of the schedule of subsistence activities to accommodate steady wage employment. This is not a static system, however, and it would be foolish to assert that any sort of equilibrium has been reached or that wage labor as a scheduling force will always remain as important as it is at present. There are currently few active subsistence specialists in Kaktovik who do not also work for wages. That is, few people support themselves solely by hunting and trading the game they procure for whatever they need that they cannot harvest themselves. Most hunters participate directly in the wage economy, and more than a few wage laborers do little or no hunting.

Economic opportunities in Kaktovik are limited due to the community's isolation (the DEW Line System now is mostly automated, and the Kaktovik station usually only has two civilian contractors in residence). Most employment is for the provision of services, either for the NSB or the City of Kaktovik. The school district provides substantial employment, but most teachers are non-Inupiat hired from other parts of Alaska or from outside of Alaska. Part-time seasonal jobs, such as construction projects, also provide employment for local residents, but also employ transient non-Inupiat contractors as well. Tourism has begun to develop on a small scale as a result of Kaktovik's proximity to the Refuge.

Contemporary Subsistence Use Patterns of Kaktovik Residents

The normative annual subsistence cycle for Kaktovik is described in Figure 3-32. This may not perfectly represent current use patterns, but is based on the best available published information and, as far as can be determined, is accurate in at least a general sense. For purposes of planning for the Project, the most critical resources will be caribou and bowhead whales, with fish and marine mammals as secondary foci and other species discussed mainly as opportunistic targets.

Caribou hunting occurs throughout most of the year, with a peak in the summer when open water allows hunters to use boats to access coastal and riverine caribou. Caribou are not taken during the break-up period when the tundra is too wet and soft for snowmachine travel but the ocean is not yet open for boat access (IAI 1990). Bowhead whaling occurs between late August and early October, with the exact timing depending on ice and weather conditions (MMS 2003). The whaling season can range anywhere from longer than one month to less than two weeks, depending on these conditions. Other marine mammal hunting (mainly seals) can take place year-round, as can hunting for birds. As a practical matter, most birds are taken during the spring and fall migrations. Furbearers and sheep are taken in the winter, when surface travel by snowmachine is possible. Fresh water fish are harvested mainly under the ice, while ocean fish are taken during the open water season. Moose are not a preferred species in Kaktovik and have had relatively restricted seasons in recent years, and use information is dated – but the proposed action is not likely to affect this use.

Whaling has most recently been resumed in Kaktovik in 1964, but only a minimal descriptive account of current whaling practices will be presented here. Kaktovik only whales in the fall, with a quota of three strikes (whether the animals are landed or not). The whaling season starts no sooner than late August and ends in September or October, generally after the community uses its three strikes. There are at least 10 crews in Kaktovik, so that even with a minimum of four or five men to a crew, most adult men are involved with whaling. Most other people in the village are involved in some support or processing capability. Whaling is truly a community-wide activity. Whaling crews use the village as their home base, leaving from the village and returning to it every day. Not all days are equally good for whaling, and there are periods when crews do not go out because of high winds and waves. When whales are spotted, the boats are arranged to intercept them in such a way that at least one should have a good shot at striking the whale. There is some competition to be the first to strike a whale, as this increases the prestige of that captain and his crew, but the process as described is mainly cooperative. Once a whale is struck, all crews in the area go to help procure the whale, haul it back to Kaktovik, and process it. Kaktovik and Nuiqsut whalers have perhaps the lowest rates of "struck and lost" whales of the 11 Alaskan whaling communities.

Kaktovik has what is essentially an intercommunity agreement with Anuktuvuk Pass under which Kaktovik muktuk and whale meat is sent to Anaktuvuk Pass and caribou is sent from Anaktuvuk Pass to Kaktovik. Caribou is a much more variable resource for Kaktovik than for Anuktuvuk Pass, and Anuktuvuk Pass does not have access to bowhead whales or other marine mammals. This is not trade in the strict sense, as in years when Kaktovik does not harvest a whale they still receive caribou from Anaktuvuk Pass, and may indeed receive more than in years during which they do harvest a whale since the nutritional need is then greater. Most of the food thus exchanged is redistributed at public functions and feasts, primarily at major holidays such as Thanksgiving, Christmas, Easter, and the Fourth of July.

Kaktovik hunters harvest several large land mammals including caribou, Dall sheep, moose, and grizzly bear. Kaktovik's annual caribou harvest fluctuates widely because of the unpredictable movements of the herds, weather-dependent hunting technology, and ice conditions. Limited only by availability and unfavorable weather conditions, caribou can be harvested almost year-round. With open water comes a period of intense caribou harvest that usually occurs in July.

Fish is an important subsistence resource for Kaktovik. The community's harvest of most other subsistence resources can fluctuate widely from year to year because of variable migration patterns of game and because harvesting technologies are extremely dependent on ice conditions and weather. Fish may be somewhat less subject to these conditions, but still exhibit large year-to-year variations, perhaps partly related to the amount of human effort devoted to fishing as a response to limitations in the availability of other resources. This makes fish an important resource for Kaktovik's subsistence system, perhaps greater than its percentage of total harvest would indicate. Moreover, in January and February, fish may provide the only source of fresh subsistence foods. Since the mid-1960s, waterfowl and coastal birds as a subsistence resource have been growing at least in seasonal importance. The most important subsistence species of birds for Kaktovik are the black brant, long-tailed duck, eider, snow goose, Canada goose, and pintail duck. Waterfowl hunting occurs mostly in the spring, from May to early July (MMS 2003). Ptarmigan are also seasonally important. Trapping furbearers as an activity in Kaktovik has decreased with time. Hunters still avidly pursue wolf and wolverine; however, by searching extensive areas for them and shooting them. This is the same pattern as is exhibited in Nuiqsut and seems to be a combination of a lack of time to check a trapline as regularly as the hunter would desire and an unwillingness to let a "strong" animal such as a wolf or wolverine linger and suffer in an unchecked trap. As for Nuiqsut, the best time for hunting furbearers is reported to be March and April. Some hunters may go out in the fall or winter, but usually conditions are poor at that time and people are more concerned with meat than with fur (ASR 1990).

Tables 3-33 and 3-34 provide an indication of the relatively high level of subsistence food harvests in Kaktovik, the importance of subsistence resources to almost all households in the community, and the relative amounts of the resources harvested by general category.

Complete subsistence-harvest surveys were conducted in Kaktovik in 1985, 1986, and 1992 by ADF&G, and in 1994 and 1995 by the NSB. These surveys are summarized in Table 3-35. In addition, surveys of caribou harvest were completed in 1987, 1990, and 1991. An earlier effort was also focused on caribou harvest for 1981-1983 (Pedersen and Coffing 1984). These numbers are presented, along with those for Nuiqsut for various years, in Table 3-36. The total caribou harvest in recent years has been reasonably consistent, averaging approximately 21,000 pounds per year, with the exceptions of a somewhat low figure in 1990 and a peak in 1985, which was a year in which no bowhead whale was landed in Kaktovik (Galginaitis et al. 2001). Thus, increased caribou hunting could have been a response to the lack of a bowhead harvest. By contrast, the documented fish harvest varied widely in these years, as did that of marine mammals. This last was due to the failure to land a whale in Kaktovik in 1985. It should also be noted that while three bowheads were taken in both 1986 and 1992, those taken in 1992 were much larger in size. Consequently, the per capita harvest of subsistence resources was higher in 1992. ADF&G considers 1992 as the “most representative” year for subsistence harvest in Kaktovik. The 1995 NSB survey is consistent with the 1992 data. Most recent subsistence documentation in Kaktovik has focused (Table 3-37) on fish and is also presented below and is at the low end of the complete survey data (and may well represent underestimates, since the focus was on Dolly Varden/char and not whitefish).

In summary, Kaktovik has a maritime orientation in terms of its overall subsistence pattern, as evidenced by the subsistence survey information. In years when Kaktovik residents land a whale, marine resources have composed 59 to 68 percent of their total subsistence harvest. Land mammals are the next largest category, ranging from 17–30 percent in those same years, with fish comprising 8–13 percent of the total, and birds and eggs making up 2–3 percent, and vegetation a smaller amount. The Kaktovik “mix” of resources is unique to the community and reflects its location. The primary marine mammal resource is the bowhead whale, but Kaktovik residents also harvest a significant number of bearded and smaller seals, and the occasional beluga and polar bear. The primary land mammal resource is caribou, but Kaktovik residents also harvest a significant number of Dall sheep, and muskox are also a potentially important subsistence resource. While Kaktovik hunters have taken moose, this is not a preferred species in Kaktovik. In terms of fish, Kaktovik’s effort seems to be split between Dolly Varden and whitefish, with the summer fishery at sites near Kaktovik being more productive than winter fishing on the lower reaches of the Hulahula River. In years when a whale is not landed, other resource use is increased, but it appears that the use of land mammals is more intensified than is fishing. This data may simply reflect that the fish resource is more variable or less abundant in the Kaktovik area in general than are land mammal resources.

TABLE 3-33: QUALITATIVE PRESENTATION OF ANNUAL SUBSISTENCE CYCLE FOR KAKTOVIK[1]

	1985	1986	1992
Percent of households harvesting resources	90.5	87.2	89.4
Estimated total pounds harvested by the community	61,663	84,060	170,939
Per capita pounds harvested	327.9	432.8	885.6
Average pounds of the resources harvested per household	1,163.4	1,501.1	2,713.3

Notes:
Source: ADF&G Community Profile Database.
[1] The years in which data were collected may not accurately represent the relative dependence of communities on subsistence harvests. 1992 is considered the “Most representative” year for Kaktovik by ADF&G.

TABLE 3-34: SUBSISTENCE HARVEST IN KAKTOVIK BY RESOURCE, 1992[1]

	Percent of Households Harvesting Resources	Estimated Number Harvested	Estimated Pounds Harvested	Average Pounds Harvested per Household	Per Capita Pounds Harvested
Fish	93.6	18,464	22,952	364.32	118.91
Salmon	25.5	50	105	1.67	0.54
Non-Salmon Fish	93.6	18,415	22,847	362.65	118.37
Land Mammals	95.7	425	28,867	458.20	149.55
Large Land Mammals	95.7	212	28,705	455.64	148.71
Small Land Mammals	46.8	213	162	2.57	0.84
Marine Mammals	89.4		115,645	1,835.64	599.13
Birds and Eggs	89.4	1,796	3,249	51.57	16.83
Vegetation	76.6		227	3.60	1.18

Notes:
Source: ADF&G Community Profile Database.
[1] The survey year considered by Alaska Department of Fish and Game to be most representative of the community’s harvest patterns.

TABLE 3-35: SUMMARY OF KAKTOVIK COMMUNITY SUBSISTENCE HARVEST SURVEYS, MAJOR RESOURCE CATEGORIES

Kaktovik Community Subsistence Harvest Surveys												
	1985			1986			1992			1995		
	Number	Pounds	% of Total Pounds	Number	Pounds	% of Total Pounds	Number	Pounds	% of Total Pounds	Number	Pounds	% of Total Pounds
All Resources	9,585	61,664	100	6,484	84,060	100	21,035	170,940	100	5,180		
Fish	6,866	11,403	18	4,416	6,951	8	18,464	22,952	13	4,426		11
Salmon	0	0	0	0	0	0	50	105	0	1		
Whitefish	3,546	2,482	4	2,402	1,682	2	8,823	6,051	4	2,358		
Other	3,320	8,921	14	2,014	5,269	6	9,591	16,796	10	2,067		
Land Mammals	714	35,491	58	382	24,946	30	425	28,867	17	178		26
Caribou	235	27,941	45	178	21,188	25	158	19,136	11	78		
Moose	4	1,893	3	1	596	1	4	2,011	1	1		
Dall Sheep	47	4,622	7	17	1,710	2	44	4,379	3	30		
Muskox	1	748	1	2	1,413	2	5	3,179	2	9		
Other	427	287	0	184	39	0	214	162	0	60		
Marine Mammals	174	10,762	17	67	49,723	59	123	115,645	68	46		61
Bearded Seal	21	3,776	6	17	2,936	3	24	4,246	2	21		
Other Seal	152	6,360	10	45	1,901	2	46	1,858	1	19		
Walrus	0	0	0	0	0	0	0	52	0	0		
Beluga	0	0	0	0	0	0	0	0	0	1		
Bowhead Whale	0	0	0	3	43,704	52	3	108,160	63	3		
Polar Bear	1	626	1	2	1,182	1	3	1,330	1	2		
Birds & Eggs	1,831	3,995	6	1,561	2,382	3	1,796	3,249	2	530		2
Vegetation	NA	13	0	58	58	0	227	227	0	NA		

Notes:
Source: ADF&G Community Information System (http://www.subsistence.adfg.state.ak.us/CSIS/) and Brower et al. 2000.
1985, 1986, and 1992 were ADF&G surveys. 1995 was a NSB survey and did not provide harvest in terms of pounds, but did provide the percentages shown for the 1995 subcategories of resources. "Pounds" for 1995 could not be calculated as for Nuiqsut, since only aggregated category percentages were provided in the published document.

TABLE 3-36: ESTIMATED CARIBOU HARVEST, BY YEAR, KAKTOVIK AND NUIQSUT

Documented Annual Caribou Harvest, Nuiqsut and Kaktovik		
Year	Estimated Harvest	
	Nuiqsut	Kaktovik
1981		43
1982		160
1983		107
1985	513	235
1986		201
1987		189
1990		113
1991		181
1992	278	158
1993	672	
1995	258	78[1]
2000	413	
2001	600	
2003	364	
2004	429	
2005	436	
2006	362	

Notes:
Source: ADF&G Community Information System (http://www.subsistence.adfg.state.ak.us/CSIS/); Brower et al. 2000; Brower and Hepa 1998; Harper 2007.
[1] Number reported as harvested – total estimated harvest not available

TABLE 3-37: KAKTOVIK ESTIMATED FISH HARVEST, SAMPLE YEARS 1985–2002

Kaktovik Fish Harvest, by Year								
Year	Reported Harvest (pounds)	Estimated Harvest (pounds)	Using	Attempting	Harvesting	Giving	Receiving
2002	3,056	9,748	76	55	47	32	47
2001	3,719	5,970	61	43	38	36	52
1992	17,123	22,952	94	83	81	70	70
1986	5,833	6,951	96	75	72	66	87
1985	9,036	11,403	100	86	81	45	93

Notes:
Source: Pedersen and Linn 2005, and ADF&G Community Information System (http://www.subsistence.adfg.state.ak.us/CSIS/).

Spatial Aspects of Kaktovik Subsistence Resource Use

Kaktovik's present subsistence area covers the northern part of the Refuge and south into the Brooks Range to the headwaters of the Hulahula River (Figure 3-33). The coastal area west of the Refuge may also be used during the summer, to Flaxman Island and Bullen Point and occasionally further west to the Shaviovik River and Foggy Island for caribou and perhaps for fishing (LGL et al. 1998). In most cases hunters seldom use, or expect to use, this entire area. To the west, some hunters refer to the Canning River as their "Berlin wall" because of the oil exploration and drilling which restricts and/or deters their crossing it, while to the east, the area beyond Griffin Point/Pokok Lagoon is usually avoided because of the lack of safe anchorages in the event of sudden bad weather (IAI 1990a). Most trips beyond the Canning River are multi-purpose summer trips, due to the distance from Kaktovik and harsh conditions in winter. This mid-Beaufort Sea area west of the Refuge is where some present day Kaktovik residents were born or grew up, so strong associations remain. Kaktovik hunters may also travel this area in the winter on snowmachine in pursuit of furbearers, but usually only on day trips, and not on a regular basis. Similarly, for bowhead whales, Kaktovik whalers indicate they would normally go no further than 15 miles west of Kaktovik (Camden Bay) and 15–30 miles east of Kaktovik. Marine mammals are generally taken relatively near the community, unless encountered opportunistically during trips for other reasons (camping trips to the west, trips to Canada to visit relatives in Canada to the east). Each of the main species will be discussed in turn, primarily summarizing the information available in IAI (1990a).

Caribou

Caribou are the staple and preferred terrestrial mammals in Kaktovik's subsistence diet (LGL et al. 1998). Kaktovik residents harvest caribou from the PH and CAH. 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. Caribou are hunted on the coast by boat in the summer, and are harvested where they are found, typically close to the community (Figure 3-34), but farther away when they are not found close to the community. The information available indicates that over half of the caribou harvested by Kaktovik residents are taken during the period from June–September, at or near coastal sites (Pederson and Coffing 1984; Coffing and Pedersen 1985; Pedersen 1990; Wentworth 1979; LGL et al. 1998). Since coastal sites are used in the winter as well as the summer, this means that well over half of all Kaktovik caribou are taken on the coast (69 percent coastal versus 29 percent inland for the years 1981-1988). Caribou harvest occurs inland during the winter when snowmachine travel is possible (LGL et al. 1998). The historic Kaktovik summer subsistence harvest area has been documented as extending from the Canadian border to Tigvariak Island (west of Mikkelsen Bay), and thus encompasses the Point Thomson area. Available information on the location of Kaktovik caribou harvest is limited and dated, but would indicates that current coastal harvest usually takes place no farther west from Kaktovik than the Canning River and no farther east than Griffin Point (Pederson and Coffing 1984; Coffing and Pedersen 1985; Pedersen 1990). For the years 1981–1988, the harvest site at the mouth of the Canning River seems to have usually accounted for less than 10 percent of the total caribou harvest (and sometimes for much less – but detailed information is not available for all years). However, for the regulatory year 1982–1983 when caribou were not as available in other areas (and the total harvest was smaller than in other years), Kaktovik hunters took 37 percent of their caribou harvest from the Canning River delta area (Pederson and Coffing 1984; Coffing and Pedersen 1985; Pedersen 1990). Thus, while the coastal areas west of Camden Bay may not be used as often as some other areas for the harvest of caribou, ADF&G still maps the Canning River Delta as part of Kaktovik's "intensive caribou use area" and the area is clearly quite important as an area for hunting when areas closer to Kaktovik that are usually productive for some reason are not.

To the east, the area beyond Griffin Point/Pokok Lagoon is usually avoided because of the lack of safe anchorage. To the west, Kaktovik residents have, as discussed above, recently (since the 1980s) confined themselves to the east of the Canning River. Some people may travel beyond the Canning River on occasion, but not on any regular basis. The most mentioned use site west of the Canning River is a summer caribou hunting and camping area to the east of Bullen Point, on the coast (IAI 1990a). This area is located approximately 10 miles (16.1 kilometers) west of the Project area, and is listed in various NSB documents as a camping and fishing area as well (a multi-use site). Brownlow Point and the delta of the Canning River in general are also identified as productive locations for the harvest of caribou and, especially in the past, for camping and fishing (IAI 1990a).

The Canning River is described by Kaktovik residents as their "Berlin wall" because of the oil exploration and drilling which restricts and/or deters their crossing it (IAI 1990a). This is consistent with Pedersen and Coffing (1984), who reported that no caribou were harvested west of the Canning River for their period of study (1981-1983), even though the Bullen Point area was acknowledged to be a very productive area for caribou and the historic Kaktovik use area for caribou extended to Tigvariak and Foggy islands. They speculate that caribou were not harvested by hunters in this area (west of the Canning River), this may be because of a number of factors including uncertainty of the caribou hunting regulations for the area. Confusion exists in the community over the different seasons and bag limits in Units 26B and 26C. Additionally, hunters may believe that much of the area is closed to the taking of big game (as is a large area around Prudhoe Bay) now that there is a considerable presence of oil and gas industry related activities east of Prudhoe Bay, both offshore and onshore, all the way to the Canning River. Possibly there were no caribou in the area for some reason when Kaktovik hunters were there, or perhaps the caribou were easily spooked by snowmachines and stayed outside of rifle range. Whatever the reason may be, Kaktovik hunters did not report taking any caribou west of the Canning River during the study. More information should be developed on this situation to bring it into better focus. Meanwhile it seems reasonable that certain mitigating measures are in order on state, federal, and privately leased lands, in and near Kaktovik's caribou hunting range to minimize potential further alienation of hunters from either the land or the subsistence resources in the area (Pedersen and Coffing 1984).

There is no reason to think that the situation is any different in 2009 than it was in 1981–1983 or 1990. A portion of the known and productive caribou hunting use area for Kaktovik has apparently not been documented to have been used since 1981 – that portion west of the Canning River (and most notably Bullen Point). At the same time, the mouth of the Canning River is included within the "intensely used" or "core" Kaktovik caribou use area. This and the Flaxman Island/Brownlow Point area are where many people who eventually moved to Kaktovik (or their parents) grew up and/or lived (see Section 3.3.2, Cultural Resources for a discussion of sites associated with historic land use and subsistence resource harvest sites in the locale). The Flaxman Island/Brownlow Point Canning River delta area was clearly important in the past, and this may be one reason that Kaktovik subsistence users maintain it as part of their intensive use area. With the proposed development of Point Thomson it will be important to ensure the continuation of this use.

Fish

The information reported in IAI (1990a) on fishing in Kaktovik agrees for the most part with the results of previous studies (Wentworth 1979; Jacobson and Wentworth 1982; Craig 1987; Pedersen 1989) and more recent work (Pedersen and Linn 2005), and is the basis for the summary provided here. Fishing can take place year-round, but summer fishing with gill nets (of various mesh size) is the most productive of the year and most of the fishing effort is directed to this activity. This open water fishing takes place at sites relatively close to Kaktovik. Jigging is done through a hole chopped in the ice, generally with an unbaited lure on the end of a stout line. Winter/spring ice fishing at inland sites is combined with sheep and caribou hunting, especially if family units camp out for any period of time for these activities. The total Kaktovik community-based subsistence fishing areas is presented in Figure 3-35, the most productive fishing sites over time in Figure 3-36, and Kaktovik subsistence harvest place names in Figure 3-37.

Winter fishing will not be treated at any length in this document, as the only site documented use site in proximity to the Project area is more than 40 miles inland on the Canning River (IAI 1990). The frequency of use of these sites was not reported, but such use seems to be in conjunction with the infrequent trips for moose to the area, and the somewhat more frequent pursuit of furbearers. The latter is especially true of spouses and families accompany the hunters, since they usually do not participate in the wide-ranging travel necessary to find and harvest the furbearers once the area to be hunted is reached. They would stay in or near camp, fishing or hunting small mammals. These areas were certainly used more for fishing in the past than they have been recently. One informant also located an area on the Aichilik River where he reported his parents spent some winters. He says that few people from Kaktovik use this area much anymore, but that the fish are still there. More commonly used winter fishing sites are all located on the Hulahula River and serve as either stopover places or base camps for multiple subsistence harvest activities. First Fish Hole is in the foothills rather than the mountains, and is used mainly for fish and caribou, and as a camping place while on the way further up the river. Second Fish Hole is perhaps the most used base camp site in the Kaktovik land use area. Access to sites further up the river is often hindered by lack of snow cover or overflows on the river. Third Fish Hole is the furthest of the most commonly used fishing locations and is at the margins of the identified caribou hunting area. Paqta (“Fourth Fish Hole”) is a good fishing location because of the creeks entering the river at this site, but access is often difficult and family groups tend to stop at one of the base camp locations nearer the village. Kangich is the furthest base camp on the Hulahula from Kaktovik and is still more difficult to reach. No informant mentioned fishing here, with sheep being the resource sought from this site. Another commonly mentioned “site” was the Lake Schrader/Lake Peters region. Informants say that the entirety of these lakes are good for fishing, that several Native allotments are located on the lakes, and that caribou and sheep hunting is very productive in this area. It is thus likely that family units camp in this area as well. Informants say that these lakes would be productive for summer fishing as well if they were accessible, but they are not (except by plane, which is too expensive).

Summer net fishing is the most productive fishing activity engaged in by Kaktovik people, in terms of number of fish caught, the weight of the catch, and the number of households that participate in the harvest. There are several productive sites very close to the village where nets are regularly set (Arey Island, Iglukpaluk – on the northwest of Barter Island, Manning Point, and Bernard Spit). People may camp at these sites or commute from the village to check the nets. There are other areas farther from the village where people establish fish camps and will stay for a while. To the west is the Canning River delta, Kanginniivik, several other areas along Camden Bay, and the mouth of the Okpilik and Hulahula rivers. To the east is the mouth of the Jago River, an area centered on Griffin Point (Browers' fish camp), the mouth of the Aichilik River, and the mouth of the Kongakut River. In addition, people will take nets with them whenever they take boat trips and if they will be in an area for some time (camping, hunting for caribou or birds) they will set the net in a likely place. That way, even if they fail to shoot any game they are likely to at least catch some fish for little additional effort. Demarcation Bay is said to be a productive location which is used in this way on trips to and from Canada. Most other locations along the coast can also be used in this way, especially to the west of Barter Island where people tend to boat more than to the east (except for trips to Canada). Again, this for the most part confirms the information in Jacobson and Wentworth 1982, although they report that the Jago has no fish in it, except for some smelt at its mouth, and that it is so shallow there that catching them is difficult. Pedersen (1989) and village informants would seem to indicate that at least some fish are caught in this area. An additional site that is inland on the Kongakut River is reported to have good summer fishing. The frequency of such use is not clear, since access would be difficult. This may be a site used more in the past than presently.

The overall use area defined by these sites is essentially the same as that described by Pedersen and Linn (2005), although that was not the purpose of that document. The historically documented use area, that represents the areas known to be productive to the fishermen in the community, extends coastally from the Shaviovik River (Tigvariak Island) in the west almost to Demarcation Point in the east (although not all coastal areas east of Kaktovik are suitable for fishing). This includes the upriver portions of the Shaviovik and Canning Rivers. However, Pedersen and Linn (2005) maps the areas considered by Kaktovik fishermen as being the most productive over time as extending from Camden Bay in the west to Demarcation Point in the east (again with coastal gaps in the eastern use area). Those sites actually used for fishing during the years of the study (2000–2002) were still more restricted, from Anderson Point in the west to Griffin Point in the east.

Bowhead Whales

The extreme limits of the Kaktovik whaling limit, the middle of Camden Bay in the west and just north of the Kogotpak River in the east, are as far as Kaktovik whalers can conceive of trying to tow a whale back to Kaktovik (Figure 3-38). The “core” whaling area for Kaktovik is from the Okpilak and Hulahula Rivers in the west to what is labeled Tapkaurak Point on the USGS base map in the east. The area extends out as far as 20 miles from the coast, although most of the time crews will stay within 12 miles or so of the shore. Nearly all whales harvested since 1964 have been struck within this “core” area and there is an explicit effort made to restrict this range (Figure 3-39 displays a subset of these strikes). Towing a whale is hard work and relatively slow, especially if there is a wind or rough seas to contend with. The farther away from Kaktovik a whale is killed, the longer the tow will be, and the greater the chance there is that at least part of the meat will spoil. As previously stated, most whales are taken within the “core” area, and most of these in relatively close proximity to the village. Note that there have been whales struck by Kaktovik whalers outside of these boundaries, but only under unusual circumstances, and well to the east of the Canning River and the Project area.

Marine Mammals other than Bowhead Whales

Relatively little locational information is available for the harvest of other marine mammals for Kaktovik. Few informants were at all specific about seal for the 1990 study (IAI 1990a). This seems to have been for a number of reasons. Far fewer seals are harvested than in the past, most of this harvest was reported to occur in the summer when seals are plentiful all along the coast as long as there is ice, and the harvest is made relatively close to the village. Jacobson and Wentworth (1982) define the most intensively used sealing area as Pokok Lagoon in the east to Collison Point in the west. This is once again the more-or-less standard limits of the Canning River in the west (oil development) and Griffin Point/Pokok Lagoon in the east (environmental characteristics) that have tended to define the overall usable subsistence range for most species so far discussed. Figure 3-40 displays this area. In essence, Kaktovik hunters can take seals in many places, and as logical people most commonly take them close to the village. If they encounter them further away, while doing something else, and want a seal, they will harvest it there. As stated by Jacobson and Wentworth (1982), ringed seal are by far the most common seal in the area, although bearded seal is preferred. Bearded seal are also larger, but it is not known which is taken more often or contributes more to the diet. Seal oil is still a very important condiment and is probably the most important current use of seal (although the meat is eaten as well).

The one exception to the above paragraph is spotted seal, which are harvested with the least frequency and are not common in the area. Informants reported that hunters had to travel to the Kongakut River area or Demarcation Bay to harvest these animals, which are desired mainly for their pelts. Jacobson and Wentworth (1982) report that the area from the Okpilak and Hulahula River mouths west to Anderson Point is also good for spotted seal, but this was not verified in other sources. The current harvest amount or level of effort expended on spotted seals is also unknown. All these possible use areas are well east of the Project area. Walrus are rarely seen near Kaktovik and are not harvested on a regular basis.

Birds

Migratory birds are harvested mainly on a seasonal basis, and hunters commonly take camping trips of several days for this purpose. None report traveling further west than mid-Camden Bay on these trips (IAI 1990a).

Furbearers

The primary areas Kaktovik hunters use for the harvest of furbearers are in the foothills and valleys near the mountains. The most defined such area lies between the Sadlerochit and Shublik Mountains, while a less-defined area is west of the Canning and north of the mountains and extends west at least to the Sagavanirktok River. Hunters say that there are sheep in the Sadlerochit Mountains, but that they do not hunt them in this area as yet. Some people may hunt furbearers east of Barter Island from a base camp located on the upper Aichilak River, most likely in the foothills and lower lands that are more accessible and productive than the mountains to the south. Since this is in March and April, they do not bother shooting any of the sheep in the area as they are not in prime condition in the spring. Hunters who want to harvest furbearers also tend to ignore caribou as targets of opportunity. For the most part, Kaktovik hunters only plan a trip for furbearers after they have laid in a reasonable store of meat. Once this is done, they can afford the relative luxury of hunting for fur. This involves extensive travel, often at high speed. Harvesting and transporting large amounts of meat would defeat the central purpose of the hunt, especially as the best territory to hunt is relatively distant from Kaktovik. Few base camps were identified for furbearer hunting activities, so it appears that most such camps are more transitory and ad hoc than for other types of hunting. Given the nature of the hunt, and the dispersed characteristic of the quarry, this in understandable (IAI 1990a).

3.3.3.5 Subsistence Use Patterns for Nuiqsut

Much of the information summarized in this section is relatively old, dating to the 1990s and before, with some more recent supplementary information. It is generally thought to represent current use patterns in Nuiqsut fairly well, but will need to be checked and verified with, at a minimum, a series of interviews with local Nuiqsut experts. After a very general description of historical land use and subsistence patterns of the "Nuiqsut" area in general, the bulk of this section will discuss the contemporary land use and subsistence patterns of the current residents of Nuiqsut. This discussion will start with a brief treatment of the normative annual round (what species are used), followed by a more quantitative presentation of amounts that are actually harvested ("dependency" and variability of resources), and then a discussion of areas used for subsistence activities, with a focus on the Project area. Much of the information for this last section is derived from IAI (1990b), which combined a synthesis of earlier published (and unpublished) material with a period of fieldwork focused on community land use patterns. This has been supplemented with the limited amount of more current information available and very limited talks with active subsistence hunters the community. It is anticipated that these contacts will be augmented by either the ER team in the near future or the EIS team some time in 2010.

Historical Land Use and Subsistence Patterns of Nuiqsut Residents

The Colville River delta has traditionally been a gathering and trading place for the Iñupiat (identified with Niglik in particular) and has always offered good hunting and fishing. Perhaps most critical for understanding how current Nuiqsut residents use subsistence resources and their patterns of land use is realizing how they (both the behavioral patterns as well as they people) are related to their forebearers and where they came from. The current residents of Nuiqsut are the descendents of people who lived a seasonally mobile subsistence live, within an area minimally defined by the habitation/subsistence sites documented by the mid-Beaufort Sea TLUI (NSB 1980). Many were much more mobile, spending their time between western Canadian arctic coast and the Noatak River, and select points in between. Seasonally inhabited sites near the present community of Nuiqsut such as Itkillikpaat, Tiragruak, and Kayuktisiluk were regularly used until the late 1940s, at which time most of the Inupiat population consolidated in coastal communities such as Barrow and Point Hope due to the presence of schools and potential employment. Only a few people, a family or two, maintained more-or-less constant habitation in the Colville River delta area. Nuiqsut was one of three Iñupiat villages in the North Slope region recognized as traditional Native communities by ANCSA, even though at the time of the passage of ANSCA there was no recognized permanent population living at those locations. The village was resettled in 1973 by 27 families, primarily from Barrow. Although they were "from" Barrow in the sense that they had lived there, many in fact identified more with and felt more comfortable living in the Colville River area (Brown 1978). They lived in tents while a school, housing, and other facilities were constructed by federal agencies (and local labor) in the summers of 1973 and 1974; goods were hauled from Barrow by tractor and snowmachine. Nuiqsut was incorporated as a city in 1975. Today, Nuiqsut is experiencing rapid social and economic change with a hotel, a large store for groceries and sundries, a water and sewer system, modern offices for the Village Corporation and the City of Nuiqsut, and the full range of infrastructure and services available and taken for granted in most modern American communities. The largest employers in the community are the NSB, the local village corporation (Kuukpik Corporation), and the city. Private sector employment is relatively underdeveloped and unemployment and underemployment are serious problems even though Nuiqsut as a whole has a higher per capita and household income than most other Alaskan rural communities. Living expenses in Nuiqsut are quite high. Oil development has expanded from Prudhoe Bay in the east towards Nuiqsut and is connected to the community with an ice road in the winter. This provides a seasonal surface transportation link between Nuiqsut and the rest of Alaska (and the country). With the start of production at the Alpine oil field in the Colville delta near the community (located 7 miles northwest of Nuiqsut) and the continuing development of oil in the NPR-A, oil and gas development now surrounds Nuiqsut on all sides except to the south. The Project is another in a long string of projects that could potentially affect Nuiqsut subsistence uses.

Contemporary Subsistence Patterns of Nuiqsut Residents

The normative annual subsistence cycle for Nuiqsut is described in Figure 3-41. This may not perfectly represent current use patterns, since it is based on historic rather than strictly current information, but is accurate in at least a general sense. It is also based on the best available information, as the most current information is proprietary and still unpublished. For purposes of the Project, the most critical subsistence resource use in terms of potential direct effects will be bowhead whales. Even though Nuiqsut is not located on the coast but approximately 25 miles inland with river access to the Beaufort Sea, bowhead whales are a major subsistence resource (MMS 2003). Bowhead whale hunting usually occurs between late August and early October, with the exact timing depending on ice and weather conditions. Ice conditions can dramatically extend the season up to two months or contract it to less than two weeks. Other marine mammal hunting takes place mainly during the open water season, with a limited amount of winter hunting on the ice. Polar bear are now mostly taken during the whaling season, at Cross Island in the fall. Caribou are available year-round, but harvest peaks in spring and late summer/early fall, reflecting Nuiqsut's location on a navigable river, availability of caribou, and hunter preferences for seasonal quality of prey. Moose are taken in the fall and are a preferred species in Nuiqsut. Furbearers are hunted in the spring, in a pattern similar to that of Kaktovik hunters, on snowmachine when tundra travel by snowmachine is possible. Fish are taken mainly in the spring, fall, and early winter and takes place almost exclusively in fresh water.

Nuiqsut has fielded whaling crews since its resettlement in 1973, but as for Kaktovik our descriptive account of its history and current practices will be brief. Nuiqsut whales only in the fall, with a quota of four strikes (whether the animals are landed or not). Nuiqsut whalers do not whale from the community, as does Kaktovik, since the community is located 16 miles inland on the Colville River. Rather, they travel 90–100 miles and use Cross Island as a logistical base. Cross Island is close to the "normal" fall whale migration and is a traditional and historic whaling site. The whaling season starts no sooner than late August and ends in September or October, either when the quota is completed or conditions become marginal enough (high winds and seas, danger of the ocean freezing) that the whaling captains decide it is time to return to Nuiqsut. Not all days are equally good for whaling, and there are periods when crews do not go out because of wind and waves. When whales are spotted, the boats are arranged to intercept them in such a way that at least one should have a good shot at striking the whale. There is some competition to be the first to strike a whale, as this increases the prestige of that captain and his crew, but the process as described is mainly cooperative. Once a whale is struck, all crews in the area go to help procure the whale, haul it back to Cross Island, and process it. There is a winch on the island which is used to pull up whales so that they can be butchered. At present the Nuiqsut crews at Cross Island are using trailers and other structures as cabins. Nuiqsut, along with Kaktovik, whalers have one of the lowest rates of "struck and lost" whales for the 11 Alaskan whaling communities. In a typical year, marine mammals (primarily whales) provide about a third of all subsistence resources harvested by the community.

Nuiqsut and Kaktovik were the first communities negotiate an agreement with the oil companies operating in the area. The impetus for the agreement was the seismic and exploratory drilling activity in Camden Bay in 1984 and 1985 that the whalers perceived as deflecting the whale migration farther offshore than would have otherwise been the case. This resulted in their traveling 30 or more miles offshore even to find whales, and not landing any whales in either Nuiqsut or Kaktovik (Kaleak 1996; Long 1996). Under the terms of the Oil/Whalers Agreement, first signed in 1986, each party had certain responsibilities. The whalers agreed not to interfere with oil exploration and development operations. The oil companies agreed not to interfere with the subsistence whale hunt and to suspend operations that may pose a hindrance to it. Both parties keep the other fully informed of the positions and intentions of all vessels in the area. Oil company vessels and facilities are available to provide assistance should it be required. Logistical support is supplied to both Nuiqsut and Kaktovik whalers, but especially to Nuiqsut whalers on Cross Island since they do not have the support infrastructure of their regular community. This arrangement has worked reasonably well until the recent past, possibly because the only offshore development in that period was Northstar (although that development was not without its arguments). However, with the resurgence in exploration and development in the offshore Beaufort Sea, and especially by Shell in Camden Bay, the Conflict Avoidance Agreement (CAA) process has broken down. Shell has not signed the CAA in the Beaufort Sea the last several years, since they could not forge a compromise acceptable to all parties with the whalers. This tension informs all other potential development projects with any potential effects on the ocean environment.

Whales are the primary marine mammal resource harvested. Nuiqsut hunters also take bearded seal (a preferred species) and smaller seals, but not in the numbers that Kaktovik hunters do. 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 hunters have taken an occasional walrus in the past, but report that in general walrus are not common east of Barrow. However, in the past few years Nuiqsut whalers have seen or heard a few walrus while out at Cross Island.

Nuiqsut hunters harvest several large land mammals including caribou, moose, and grizzly bear. Nuiqsut's annual caribou harvest fluctuates widely because of the unpredictable movements of the WAH, CAH, and TH (whose ranges overlap the Nuiqsut hunting area), weather-dependent hunting technology, and ice conditions. Limited only by availability and unfavorable weather conditions, caribou can be harvested almost year-round. The open water period allows the greatest access to caribou, with harvest peaking in the spring and late summer/early fall.

Fish is an important subsistence resource for Nuiqsut, and usually contributes about a third of all subsistence resources harvested by Nuiqsut residents. The community's harvest of most other subsistence resources can fluctuate widely from year to year because of variable migration patterns of game and because harvesting technologies are extremely dependent on ice conditions and weather. Fish may be somewhat less subject to these conditions, but still exhibit large year-to-year variations, perhaps partly related to the amount of human effort devoted to fishing as a response to limitations in the availability of other resources. This makes fish an important resource for Nuiqsut's subsistence system, perhaps greater than its percentage of total harvest would indicate. Fishing is one of the most important subsistence activities in Nuiqsut, and probably the one in which the largest percentage of the population participates. Fishing can take place at almost anytime of the year except the middle of winter (when the ice is too thick) and the period two to four weeks after break-up (when the water is too high and muddy). Fall net fishing under the ice is easily the most productive season, however, with summer net open water fishing being somewhat less productive, and winter jigging ranking last in terms of the amount caught. There is, however, an element of recreation or enjoyment associated with jigging itself that is absent from the techniques used during the other two periods of fishing. Although people enjoy being at summer fish camp, not too many express a great love for the actual task of minding their nets. Since the mid-1960s, waterfowl and coastal birds as a subsistence resource have been growing at least in seasonal importance. The most important subsistence species of birds for Kaktovik are the black brant, long-tailed duck, eider, snow goose, Canada goose, and pintail duck. Waterfowl hunting occurs mostly in the spring, from May to early July (MMS 2003).

Tables 3-38 and 3-39 provide an indication of the level of subsistence food harvests in Nuiqsut and the resources harvested. Of note is that Nuiqsut harvested a bowhead whale in only one of the years in which a complete subsistence-harvest survey was conducted—1993. More recent harvest information (1995, included in Table 3-40) for selected subsistence resources is available and also presented and discussed below. The village's whaling success since the early 1990s has been such that 1993 was the more typical year and is identified as such by ADF&G. Conceptually, the Nuiqsut subsistence harvest can be divided into thirds—a third each for fish, caribou (and moose), and marine mammals. Years when whales are not harvested require more use of fish and caribou, as reflected especially in 1985 (Galginaitis et al. 2001). That is, subsistence is a variable, flexible, and adaptable means of production. The increased use of one resource buffers the decreased availability of another. Birds and eggs provide a small percentage of the subsistence harvest, and plants yet a smaller amount (LGL et al. 1998; ADNR 1999). Although Nuiqsut is located approximately 100 miles (161 kilometers) west of Point Thomson, residents may occasionally use the area to meet part of their subsistence needs (Figure 3-42) – primarily for marine mammals. This "far away" area has not been reported to be used in the last 10 years and probably reflects a pattern of Nuiqsut hunters not traveling as far to hunt marine mammals as in the past (Figure 3-43). The first whale landed by a captain from Nuiqsut was taken near the mouth of the Canning River and Flaxman Island, and the second somewhat west and north of that location. All since then have been struck no further east than Bullen Point. Factors such as the need to fit subsistence activities into the responsibilities of employment, and the availability of equipment that allows a hunter to essentially shorten the time required to harvest subsistence resources in some ways has focused hunting effort on areas closer to the village. Employment and the cash economy are in many ways simply other sorts of economic resources that have been incorporated into the Inupiat "subsistence economy" since Euroamericans first contacted them.

TABLE 3-38: HARVEST OF SUBSISTENCE RESOURCES IN NUIQSUT, 1985 AND 1993 [1]

	1985	1993
Percent of households harvesting resources	97.5	90.3
Estimated total pounds harvested by the community	160,035	267,818
Per capita pounds harvested	399.2	741.7
Average pounds of the resources harvested per household	2,105.7	2,943.0

Notes:
Source: ADF&G ND
[a] The years in which data were collected may not accurately represent the relative dependence of communities on subsistence harvests.

TABLE 3-39: SUBSISTENCE HARVEST IN NUIQSUT BY RESOURCE, 1993 [1]

	Percent of Households Harvesting Resources	Estimated Number Harvested	Estimated Pounds Harvested	Average Pounds Harvested per Household	Per Capita Pounds Harvested
Fish	80.6	71,897	90,490	994.39	250.62
Salmon	35.5	272	1,009	11.09	2.79
Non-Salmon Fish	79.0	71,626	89,481	983.30	247.83
Land Mammals	75.8	1,290	87,390	960.33	242.03
Large Land Mammals	74.2	691	87,306	959.41	241.80
Small Land Mammals	41.9	599	84	0.93	0.23
Marine Mammals	37.1	113	85,216	936.44	236.01
Birds and Eggs	75.8	3,558	4,325	47.53	11.98
Vegetation	71.0		396	4.36	1.10

Notes:
Source: ADF&G ND
[1] The survey year considered by ADF&G to be most representative of the community's harvest patterns.

TABLE 3-40: SUMMARY OF NUIQSUT COMMUNITY SUBSISTENCE HARVEST SURVEYS, MAJOR RESOURCE CATEGORIES

Nuiqsut Community Subsistence Harvest Surveys									
	1985			1993			1995		
	Number	Pounds	% of Total Pounds	Number	Pounds	% of Total Pounds	Number	Pounds	% of Total Pounds
All Resources	69,436	151,831	100	76,858	267,818	100		51,669	
Fish	68,153	70,609	47	71,897	90,490	34	15,200	15,345	30
Salmon	441	1,366	1	272	1,009	0	10		
Whitefish	58,733	59,701	39	64,711	77,671	29	14,532		
Other	8,979	9,542	6	6,914	11,810	4	658		
Land Mammals	1,224	67,866	45	1,290	87,390	33	305	32,743.5	
Caribou	513	60,021	40	672	82,169	31	258	30,186	58
Moose	13	6,650	4	9	4,403	2	5	2,557.5	5
Dall Sheep	0	0	0	0	0	0	0		
Muskox	0	0	0	0	0	0	0		
Other	698	1,195	1	609	818	0	42		
Marine Mammals	59	13,355	9	113	85,216	32	24	1,023	2
Bearded Seal	15	2,675	2	6	1,033	0	0		
Other Seal	42	1,756	1	103	7,277	3	24		
Walrus	2	1,467	1	0	0	0	0		
Beluga	0	0	0	0	0	0	0		
Bowhead Whale	0	7,458	5	3	76,906	29	0		
Polar Bear	0	0	0	1	0	0	1		
Birds & Eggs	0	0	0	3,558	4,325	2	627	2,557.5	5
Vegetation	0	0	0	NA	396	0	NA	0	0

Notes:
Source: ADF&G Community Information System (http://www.subsistence.adfg.state.ak.us/CSIS/) and Brower and Hepa 1998.
1985 and 1986 were ADF&G surveys. 1995 was a NSB survey and did not provide harvest in terms of pounds, but did provide the percentages shown for the 1995 subcategories of resources. "Pounds" for 1995 were backcalculated using the range of conversion factors for the ADF&G surveys and so are only rough estimates. Further, the 1995 survey states that it under represents the harvest of whitefish.

Both Nuiqsut and Kaktovik have relatively household harvests of subsistence resources, although in their "representative" years Nuiqsut's is slightly larger. The distribution among resource categories is also quite different. For Kaktovik, over two thirds of the harvest by weight is from marine mammals, as might be expected from its location on the ocean and not proximate to a navigable river. Nuiqsut, on the other hand, has a much more consistent and diversified subsistence resource base, although the 1995 survey presents a challenge of interpretation.

In summary, Nuiqsut has more of an "inland" orientation in terms of its overall subsistence pattern, as evidenced by the subsistence survey information summarized in the tables. This reflects Nuiqsut's inland location on the Colville River. However, this is combined with the whaling experience many of its original settlers had acquired while living in Barrow prior to the resettlement of Nuiqsut, and the opportunity to whale at a productive and culturally relevant site relatively distant from Nuiqsut. In years when whales are landed, marine mammals, fish, and land mammals each represent about one third of the total community subsistence harvest. In years when a whale is not landed, the contributions from both fish and land mammals are increased – and it is likely that the absolute amount of these resources that is harvested would also be increased. This reflects the report that many of the original families that resettled Nuiqsut in 1973 came not only because of family ties to the area, but also because of the abundant and diverse subsistence resources available in the area (Brown 1978; Galginaitis et al. 1984).

Spatial Aspects of Nuiqsut Subsistence Resource Use

Nuiqsut's total subsistence use area is usually presented in terms of the total area used at some time by the current population (Figures 3-42 and 3-43). It is a large area somewhat hard to briefly describe, but extends coastally west almost to Barrow and east to the Canning River and encompassing the waters of Camden Bay. The use area extends south to the headwaters of the Kuukpik and Colville Rivers from about the Kuparuk River in the east to Smith Bay in the west, and includes most of NPR-A south and east of Barrow. As was the case for Kaktovik, this use area represents not only current use patterns, but also retains evidence of past patterns may now represent potential use or "insurance" areas. For Nuiqsut users the area no longer much used encompasses much of the Kuparak and Prudhoe Bay areas to the east of Nuiqsut, due to industrial development in that area and some concern over the quality or safety of subsistence resources in that region (Galginaitis et al. 1984; Galginaitis 1990b). This map should not be interpreted to mean that Nuiqsut residents do not use areas beyond the boundaries of this area. Some hunters, especially those after furbearers in the winter, will travel as far as Kaktovik, Anaktuvuk, or Barrow in their travels. Some Nuiqsut whalers regularly travel to Barrow in the spring to whale. Some hunters undoubtedly still go east to hunt for caribou on occasion. Most hunters maintain that the area east of Nuiqsut is no longer suitable for most subsistence uses. Perhaps because the areas to the west and south of Nuiqsut are regularly used by many hunters, and development in that area is expanding, there are complaints about the interference of industrial activities (aircraft overflights, noise in general, pipelines) in this area as well. All of these inform not only how Nuiqsut residents perceive any newly proposed development project, but also how people in other North Slope communities react to those projects.

The next sections will discuss the primary subsistence resources used by Nuiqust residents in spatial terms, to allow for the later evaluation of the likely potential impacts of the Project on Nuiqsut subsistence uses. For reasons that should become obvious, the main resource of concern will be bowhead whales.

Caribou

This section will first present information from IAI (1990b) and then more current information summarized in BLM 2004. There is no readily available map of the Nuiqsut area currently used to harvest caribou, other than the information for caribou displayed by Figure 3-42. In 1990 Caribou are perceived by Nuiqsut residents to be so ubiquitous and readily available that it was difficult for them to indicate areas where they specifically hunted for caribou. Thus, the entire area was used at one time or another, so to point out part of the range over other parts may in fact be misleading. Caribou can be hunted year-round, but there are times of the year when they are only hunted if there is an immediate need for meat. Most hunters prefer not to go out in the heart of winter due to limited daylight and the unpredictability of the weather. June and July also tend to be low activity months for the harvest of caribou, although they are usually locally available. Their condition tends to be poorer than later in the year and the relatively high temperatures makes preserving the meat a problem. More people do take caribou in June and July than in the past, however, perhaps due to larger and faster boats and home freezers. Most of the caribou taken in these months tend to be shot at or near fish camps in the Colville River Delta.

Most informants clearly conceived of the best caribou hunting time as summer and fall. Most indicated that the coastal areas were the most productive for caribou hunting and that they used boats to access the resource. Although the entire coastal region and Colville River Delta was said to be good, the Kogru River area and the upper Harrison Bay regions were reported to be especially productive areas in the summer. The area around Atigaru Point and below it were also very productive areas, but the water is so shallow there that one must know how to gain access to use this area. Other informants were quite insistent that the Colville River Delta and other river systems were vital summer caribou harvest sites as well (for example, the upper Itkillik and Colville). These same hunters will also take caribou when they are at summer fish camp, but usually only for immediate consumption or just before they return to the village, since it is difficult to preserve the meat at this time of the year. They prefer to take caribou in August, when the caribou are in good condition, water levels are usually high enough to allow travel up the rivers or along the coast, and preservation is not such a problem. This is also one of the preparations for whaling. Caribou will be hunted by boat through September, although fall whaling and the beginning of the rut season makes August the preferred harvest month.

The Cape Halkett area was said to be about the effective western limit of caribou hunting by boat. Hunters do sometimes range farther to hunt caribou, but only if they want to travel in that area anyway and happen to come across some animals, or if they have been unable to locate caribou at a closer location. Normally, hunters can find caribou closer to Nuiqsut than Cape

Halkett and consider a trip to Cape Halkett just for caribou to be too long a trip. Evidently, Nuiqsut boaters have tended to go west more than east recently. Olliktok Point is said to be the effective eastern limit to hunting caribou by boat, although it is clear that people use boats to get to summer camps as far east as Beechey Point and that they hunt caribou from these camps. The primary seal hunting area also extends far enough east to include Pingok Island, as is discussed below. The general impression is that Nuiqsut hunters have been reluctant to use this area because of their fears of the effects of oil development in the area. The hesitancy seems to have been based on assumptions that access to the area would be physically difficult because of the oil facilities there, that the oil companies would be overtly hostile to such access, that the animals would not be plentiful, and that the animals might not be healthy.

Caribou are hunted in the late fall, winter, and spring using snowmachines. The effective primary land use area is effectively the same as in the summer. Cape Halkett is still the farthest that hunters wish to go on a regular basis, and few hunters go east of Nuiqsut to hunt because of the Kuparuk oil field. Most Nuiqsut hunters consider on-shore oil fields as off limits to hunters. The most significant difference between the “summer” and “winter” ranges is that all of the interior is accessible in the winter, whereas in the summer hunters are restricted to the rivers and the coast.

As was true of caribou in the summer, informants say that usually there is no lack of caribou in the winter and there is no real concern about the “best” spot to locate them. They are usually near the village. In fact, during field work in February and March, 1990, caribou were observed (and hunted) near the dump, airport, sewage lagoon, and ice road. Informants did point out Atigaru Point as a dependable winter caribou harvest location if caribou could not be found anywhere else. In years with a great deal of snow, when caribou tend to be scarce, hunters say that the uplands east of the Colville, southeast of Nuiqsut, tend to be productive. The winds sweep the snow off so that the caribou can get at their feed in this area. Traveling in this area is not that bad and although there has been a good deal of seismic exploration in the area there had been little real development as yet. Thus, this area south of the Kuparuk oil field was still considered “open” to hunting and was included as a very significant area of the caribou hunting range.

Harvest location data for caribou collected by the NSB (Brower and Hepa 1998; NSB 2003) and ADF&G (2001, 2003) indicate that north of Nuiqsut the primary harvest areas for caribou include the Nuiqsut locality itself, the Colville River Delta, the Nigliq Channel, and the Fish and Judy creeks area. To the south of Nuiqsut, the Colville River provides access to areas and sites such as Itkillikpaat, Ocean Point, Itkillik River, Umiat, and the confluences of the Anaktuvuk and Chandler rivers. These are all areas documented by IAI (1990b) and generally associated with TLUI multi-use sites. These harvest locations can be used in winter (October–May), summer (June–September), or both, and they can be accessed by foot, boat, all-terrain vehicle, and snowmobile (BLM 2004).

Summer hunting is done primarily by boat after the river ice breaks up. Hunters can go east along the coast from Smith Bay east to the Sagavanirktok River, using intermediate sites such as Oliktok Point, several barrier islands, and all channels of the Colville River Delta – or Fish Creek, Judy Creek, or other areas west to Cape Halkett. Hunters also go south on the Colville

River beyond Umiat, passing Itkillikpaat, Ocean Point, Signal Hill, and Umirak en route. These trips upriver are taken by boat in the summer, in the fall when moose and caribou can be harvested, and by snowmachine in the winter in pursuit of caribou and furbearers. Nuiqsut hunters also travel up the Itkillik, Chandler, and Anaktuvuk rivers by boat and snowmachine. There are many camps and cabins in the area of Fish and Judy creeks, throughout the Colville River Delta, and up the Colville River to the south that are used for summer and winter caribou hunting (BLM 2004).

There are monthly and seasonal differences in the proportion of caribou harvested in the study years of 1993, 1994 through 1995, 2000, and 2001, with summer (defined as the open water period, including June, July, August, and September) harvests providing approximately 60 percent of the harvested caribou. For the four data years, July (23 percent) and August (24 percent) are the months with the greatest cumulative caribou harvests. According to several hunters, October (16 percent) is a preferred month for hunting caribou, because the caribou have by then accumulated a thick layer of fat. September (8 percent) is normally consumed with whaling activity, and meat from caribou hunted in August is provided to whaling crews. March (6 percent) represents the beginning of spring, with longer days and warmer weather encouraging hunters to go out on the land again and harvest caribou (BLM 2004).

Winter harvests take place after the rivers and lakes have frozen over and snow covers the tundra, allowing for a greater overland hunting range using snowmachines. Winter caribou harvest sites range from the vicinity of Admiralty Inlet and Teshekpuk Lake in the west, to the Franklin Bluffs area east of the Dalton Highway, south to Anaktuvuk Pass, and along the northern foothills of the Brooks Range. Caribou are hunted as needed (and available) while hunters pursue wolves, wolverines, and foxes southeast of Teshekpuk Lake, in the Brooks Range foothills, the Kuparuk Hills, and east of the Colville River. Subsistence caribou hunting independent of the furbearer harvest continues all winter throughout the Fish and Judy creeks area, along the Nigliq Channel, and south along the Colville and Itkillik rivers. During the coldest months, many hunters stay closer to Nuiqsut, venturing farther out as spring approaches (BLM 2004).

For all seasons, the greatest proportion of caribou for which harvest locations are known for 1993, 1994 through 1995, 2000, and 2001 were taken at Fish and Judy creeks, in the Nuiqsut locality itself, and in the Colville River Delta including Nigliq and the Nigliq Channel. The Nuiqsut area itself is the second largest winter harvest location and fourth largest summer harvest location. During the years for which data is available (1993, 1994 through 1995, 2000, and 2001), 41 percent of the caribou harvested were harvested in the Colville River Delta and 25 percent harvested in the Fish and Judy creeks area. Thus, 66 percent of the caribou harvested in this time period were harvested in these two areas (BLM 2004).

Fish

All information in this section is extracted or summarized from IAI (1990b) unless otherwise stated. Figure 3-42 also displays the best available information for Nuiqsut fishing locations. There are relatively few locations where nets are set for the more productive fall/winter fishery. This is not because these are the only productive locations, but seems to be because they are dependable spots and people like to fish together so that they can watch each other's nets, help out when it is necessary, and make it somewhat of a social activity (this is even more true of the summer fishery). Also, it is necessary to keep holes chopped in the ice to set and pull the nets, and after one person is finished fishing for the season another may set his nets in the same spot so that he can use the pre-existing holes. Also, although the general locations where people set nets are the same from year-to-year, the precise locations are dependent upon conditions at the time. Informants say that this is what separates an experienced fall net fisherman from a novice. The novice will set his net in the same place as he has before, regardless of whether conditions are the same or not whereas the experienced fisherman will examine the conditions, note similarities and differences with previous seasons, and adjust the location and depth of his net sets accordingly.

There are five main fall/winter net fishing locations in the Colville delta (Craig [1987] discusses four, but his is a subsistence fishery report and does not discuss the commercial fishery also existing in the delta). They will not be detailed here (IAI 1990a; BLM 2004) since they are in the near proximity of Nuiqsut and distant from the Project. Fish Creek could also be used as a fall/winter net fishing location, but informants were united in maintaining there was no need to travel to Fish Creek when there were sites just as productive closer to the village.

There are also a limited number of localities used to set nets in summer, in a way similar to the fall/winter net fishery. The eastern part of the delta is apparently not used at all (some informants suggested this was to avoid contact with the operators of the commercial fishery, but it could also be influenced by the desire to keep the main channel of the river open for boat traffic). There are perhaps four diffuse areas used, which again are detailed in IAI (1990b) and BLM 2004.

The first summer net area is the Nechelik Channel between Nuiqsut and Wood’s Camp (N-61 and N-58 respectively). Although there are some nets set near Nuiqsut, most people prefer to be at least 3 miles downstream and preferably somewhere from Nanuk (N-60) to Wood's Camp. This seems to be for two reasons. First, the traffic and dust from the village makes processing the fish caught near the village in summer difficult. Second, most of the fish camps are located at or beyond Nanuk and people take the opportunity in the summer to spend weeks or months away from the village at these camps. This is an explicitly recognized time for relaxed socializing and informants rank the ability to visit nearby fish camps as a major locational factor for their fish camp and/or net locations. In addition to these locations, Nuiqsut residents also fish in the other locations that they happen to find themselves. Thus, the family which has a camp at Beechey Point will set nets there. Those camping on the coast near Olliktok Point or other places may well set nets as well. Nuiqsut informants are almost unanimous in saying that they do not use the Teshekpuk Lake area, even though they may travel through it on occasion. It is simply too far to bother to transport fish. If they are in need of food to eat on the way, they may fish or shoot a caribou, but not otherwise. When they used dogteams they say it was different and this was an important area for them. In 1990 the only person who fished at all in the Teshekpuk Lake region was a summer resident of Nuiqsut who otherwise lived the rest of the year in Barrow.

The only significant difference that BLM (2004) from IAI (1990b) in terms of locational fish data was their report that Nuiqsut fishermen also use coastal areas east to the Kuparuk River and fish around several barrier islands, including Thetis and Cross islands. There is no information on what level of effort or what percentage of the total fish harvest is accounted for by these sites, but it is probably relatively small.

Bowhead Whales

The general Nuiqsut harvest area for bowhead whales is located off the coast between the Kuparuk and Canning rivers. This area seems to be conceptualized by the whalers as bounded by the farthest distance from which they would be willing to tow a whale back to Cross Island. The first whale taken by a Nuiqsut crew happened to be landed at the easternmost boundary of this area in 1973, in shallow water off the Canning River Delta. It was butchered on Flaxman Island. The next whale taken by a Nuiqsut crew, in 1982, was also taken near the Canning River, but farther off the coast and a little more west, and was reported to be have been butchered on Narwhal Island. The next whale taken by a Nuiqsut crew, in 1986, was struck near Cross Island and butchered on Cross Island. Cross Island has been used as a base camp for most Nuiqsut whaling crews since at least the early 1980s (one crew based itself on Narwhal Island until some time in the early 1990s), and since the early 1990s all Nuiqsut whalers have whaled from Cross Island. All of their documented whale strikes are enclosed within an area extended from about the Midway Islands in the west to Bullen Point (or a little further east) in the east. There is strong evidence that this is the *de facto* Nuiqsut whaling area, although some Nuiqsut whaling captains will set the eastern boundary as the Canning River/Flaxman Island or even mid-Camden Bay. Given the logistical problems encountered by a successful Nuiqsut crew even under the best of circumstances, however, it would be unusual for a captain under current operating procedures to strike a whale outside of the more circumscribed areas. Once a whaling captain reaches about 20 miles from Cross Island, he starts to consider the length of the tow back should he strike a whale. Only when whalers cannot find whales closer to Cross Island than 20 miles do they look and strike at farther distances (Galginaitis 2009). Figure 3-42 displays a “Whale Use Area” that extends all the way to Kaktovik. This reflects one year when conditions were too poor to whale from Cross Island and the Nuiqsut whalers simply continued on to Kaktovik and whaled from there, along with the Kaktovik whalers. Figure 3-44 displays the GPS tracks for the 2001–2007 Cross Island subsistence whaling seasons. The tracks for 2008 fall within this same general pattern, while those from 2009 extend to about Pole Island in the east. While not defining this as the easternmost boundary of Nuiqsut’s bowhead whale use area, it has been a pragmatic limit in the recent past. Of more importance for potential effects analysis, however, is the potential for whales coming from the east to encounter noises or objects that will deflect the overall migration farther offshore and away from Cross Island and the whalers. This is similar to the issue discussed above for caribou for Kaktovik. Thus, Nuiqsut whalers are very sensitive to the potential effects of any coastal or offshore development project east of Cross Island.

Marine Mammals other than Bowhead Whales

Relatively few Nuiqsut hunters take many seals. Many people relate this to the shift from dogs to snowmachines, and the fact that relatively few people have a preference for seal meat. Seal oil is still an important condiment in almost all households, however, so that some seal hunting (especially for ugruk) is always done. It seems that there are a few families with a maritime orientation who account for most of the seals taken. There is fairly good agreement among all informants that the prime sealing area is in front of or off of the delta area (the area centered on Thetis Island). Thetis Island is the most commonly used base camp for this area, as people often want to stay out several days. This “main area” extends as far west as Fish Creek and as far east as Pingok Island. Other sites used as base camps in this area are (from west to east) the Spy Islands and Pingok Island. Some people in 1990 indicated that they sealed as far west as Atigaru Point, which they used as a base camp, and as far east as the Cottle Island/Long Island area. They would seal in these areas before break-up by snowmachine, but most seal hunting is in the summer by boat and concentrates on ugruk. Camping trips of a week to two weeks to the more eastern islands were not uncommon in 1990 (IAI 1990a). The sealing area represented in Figure 3-45 essentially represents this description. The more recent Nuiqsut use area for seal is displayed in Figure 3-45.

Cross Island is also said to be very productive for sea mammals, but is too far away from Nuiqsut to be used on a regular basis. During whaling most captains do not want their crew’s attention to be diverted by hunting other species, so that Cross Island has not been used much except as a base camp for whaling. In the past nine whaling season, two ugruk have been taken (in two different seasons) and a few “regular” seals. The smaller seals were taken for consumption by the whalers while the uguk were butchered and sent back to Nuiqsut. One hunter, who has whaled in the area and seen the abundance of ugruk and seal, has indicated that he may begin to hunt the area in the summer. His main interest would be ugruk. The primary facilitator for this was his buying a second boat and his son being old enough to handle such a boat on his own. Hunters very much prefer to go with at least two functional machines (whether boats, snowmachines, or ATVs) when going out any distance, as a safety feature. It is possible, therefore, that Cross Island will become part of the typical sealing range of Nuiqsut in the future (IAI 1990a; Galginaitis 2009).

BLM (2004) essentially collaborates this pattern. It reports that Nuiqsut hunters take seals along the coast and offshore from Cape Halkett in the west to Foggy Island Bay in the east. In April and May, hunters ride out to Harrison Bay on snowmachines and look for breathing holes, cracks in the ice, and open water where seals could surface to breath. By the second week in June, open waters on the Colville River and much of Harrison Bay allow hunters to take boats out on a route locally called “around the world,” following the Nigliq Channel to Harrison Bay, west to Atigaru Point, then along the ice edge out as far as 28 miles, then to Thetis Island, east to Oliktok Point, then back south through the main channel of the Colville River. Thetis Island is used as a shelter should the weather turn bad, as it is crescent shaped and provides protection from wind in three directions.

The relatively few polar bears taken by Nuiqsut hunters are shot primarily at Cross island during the whaling season. Most polar bears killed are "nuisance" bears who are bothering the whalers or approaching the butchered whale(s). A few bears are taken because a hunter wants to use the skin, and some people (and especially elders) like to eat polar bear on occasion. A hunter must first obtain the permission of his whaling captain before he kills a bear, since it does require a significant effort to butcher a bear and to take care of the skin, and the crews are on Cross Island to whale and not to hunt polar bear (Galginaitis 2009).

Walrus have been encountered only infrequently by Nuiqsut hunters in the past, but in two of the last nine years Nuiqsut whalers at Cross Island have seen and taken walrus. Different whaling captains again have different ideas about the wisdom of doing so. Some think it takes time and energy away from what has become a rather limited window for whaling. Others view it as a good opportunity to supplement the overall harvest.

Birds

The typical response to a question about where people hunted ducks and geese was "anywhere." As with fish and caribou, waterfowl are seen as being so ubiquitous that when they are present one can harvest them in almost any location. However, as with fish, the actual number of harvest areas seems to be relatively small, and are displayed on Figure 3-42. Within these areas the particular harvest site may vary from year-to-year, and people tend not to camp in the same exact spot every year, but the tendency is to return to the same general area to hunt waterfowl from one year to the next. People said that the entire coast over to Beechey Point, and the entire Colville down to Sentinel Hill, is productive for waterfowl. The areas mentioned with most frequency, however, were Fish Creek, the Itkillikpaat area, and Ocean Point. All share the characteristic that they are close to the village, yet far enough away to be a change, and are good camping locations. As with summer fish camp, the opportunity to hunt and relax with one's friends and neighbors outside of the village is said to be one of the main attractions of the activity. Some fishing may be done in conjunction with a camping trip that also results in the harvest of some waterfowl. Waterfowl hunting is usually an activity that takes place within a context that allows other subsistence activities as well (IAI 1990a).

Informants went to great pains to point out that the opportunity to harvest waterfowl on the North Slope is very short, and some times they have what is in effect a "one-day" season. The "best spot" to shoot from varies from year-to-year, although areas that are productive one year can be expected to remain productive in the future. Variable conditions such as the degree of wetness, temperature, wind direction and speed, cloud cover or fog, etc. influence where the waterfowl fly. Since waterfowl are shot while migrating as flocks, a successful harvest depends on placing oneself within range of where such a flock is going to fly. Informants report varying success, but claim to never fail to harvest at least a few birds (IAI 1990a).

Again, the 1990 pattern was found to still be the case 10 years later:

> *Waterfowl harvested by the Inupiat of Nuiqsut occupy two habitats in the greater area. Ducks, geese, and brant nest and molt in the wet tundra to the north. Eiders nest on the sandy areas of the Colville River Delta and the barrier islands, and molt after their arrival. Both groups of waterfowl raise their young in the area until fall, when they migrate south. Nuiqsut hunters harvest waterfowl in May and June during the migration using snowmobiles and boats. Geese hunting areas include the Fish Creek and Judy Creek areas, the Colville River Delta, the area around Nuiqsut extending to the Fish and Judy creeks area, along the Colville River up to Sentinel Hill, the area around Ocean Point, and along the Itkillik River (BLM 2004).*

Furbearers

Nuiqsut furbearer hunters concentrate on the area of flats and river beds west of Nuiqsut and to the east of the Colville (IAI 1990a). BLM (2004) describes this area as extending "…from the eastern edge of the Colville River Delta along the coast almost to Admiralty Bay, south along the Ikpikpuk River to the Colville River and eastward to the Toolik River, north and across the Dalton Highway to Franklin Bluffs, and west and north back to the Colville River Delta." One representation of this area is displayed on Figure 3-42. Judy and Fish creeks accounted for about 50 percent of the wolverine and wolf harvests for the years for which at least some harvest locations are known (1994 through 1995, 2000, and 2001). It is clear, however, that the Nuiqsut range for hunting furbearers is potentially much greater than has been indicated. Basically, anywhere that a Nuiqsut hunter can reach is within his furbearer range. No other terrestrial subsistence resource inspires as much effort as the pursuit of furbearers. The important limitation seems to be gas for the snowmachines. In Kaktovik, hunters figure that a week trip to the mountains (60–80 miles) for furbearers will consume a drum of gas, and it is reasonable to assume the same as a minimum for a week-long trip out of Nuiqsut. Combined with this is the wear such activities puts on equipment. There is not much of a commercial market for furs, but the internal village and regional demand for furs ensures that a hunter can trade or sell his pelts and obtain some return (IAI 1990b). As BLM (2004) states:

> *"The relatively small numbers of wolves and wolverines harvested belies their importance to the community in several ways. The pursuit of furbearers is a friendly, competitive pursuit both within the village and between villages, primarily for males, and has important functions in teaching younger hunters the landmarks and resources of a very large area. Occasionally furbearer hunters will encounter people from other villages on the tundra also engaged in furbearer hunting, fostering connections between villages in a mostly male social context. Wolf and wolverine fur continues to be an important and highly valued component in Inupiat clothing. There is [thus] an economic interest in fur hunting despite the relatively poor commercial market for fur,"*

It should be noted that individual hunters in Nuiqsut have reported taking 15–18 wolves in one season (1989), although this cannot be considered typical and was accomplished by an especially avid furbearer hunter (IAI 1990a).

Moose

Moose have become an important species for Nuiqsut hunters. They are hunted by boat in August on the Colville, Chandler, and Itkillik Rivers. After August (and sometimes even in August) the water levels in these rivers tends to be too low, preventing access to the best hunting spots. Whaling starts in September in any event. Nuiqsut hunters do not hunt moose by snowmachine as the animal is simply too large and difficult to transport in that way (IAI 1990a) – see that reference for more detailed information). BLM (2004) reports a somewhat wider range of hunting areas, listing the Colville River Delta area upstream to Ninuluk Creek, the drainages of the Itkillik River and Fish and Judy creeks, and some side streams off the Colville River. Moose use areas are displayed on Figures 3-42 and 3-45.

3.3.3.6 Historical and Subsistence Relationships Among Anaktuvuk Pass, Kaktovik, and Nuiqsut

Pre-contact North Slope Inupiat lifeways have been discussed in terms of the Tagiugmuit (or Taremiut - coastal) and Nunamiut (inland) people – the former depending primarily on marine mammals and the later on caribou and inland resources (Schneider and Libbey 1979). This dichotomy oversimplifies the complexity of pre-contact Inupiat social organization (Burch 1976), but it will suffice for this report. Anaktuvuk Pass, and to some extent Nuiqsut and Atqasuk, represent contemporary “Nunamiut” communities, in that most people in Anaktuvuk Pass and a significant portion in the only two communities are descended from people who lived a “Nunamiut” lifestyle in the past.

Prior to Euro-American contact, the Tagiugmuit and Nunamiut interacted and traded at traditional trading fairs at several coastal sites such as Nigliq (Colville River Delta), Flaxman Island, Barter Island, and other sites. The trade fairs essentially ended by 1918 (NSB 1980) because the interior of the North Slope was largely depopulated around that time. The Inupiat population was concentrated in a limited number of coastal settlements during the late 19^{th} century until about 1934. Families started to return to live in the interior area about 1939, and transitioned to a more sedentary lifestyle centered on Anaktuvuk Pass after about 1951 (Spearman et al. 1979). When ANCSA fostered the resettlement of Nuiqsut and Atqasuk, former “inland” Inupiat (and some others) founded the communities of Nuiqsut and Atqasuk (Libbey et al. 1979; Pedersen et al. 1979). Thus, all three communities share an historical inland orientation.

Each community manifests that inland orientation differently. Atqasuk, due to its proximity and relatively easy access to Barrow, has access to both marine and inland resources. Nuiqsut, although located inland on the Colville River, maintains access to marine mammals through a unique investment of time and capital in whaling from Cross Island, a site 90–102 miles from Nuiqsut. Anaktuvuk Pass maintains access to marine resources through the traditional mechanism of sharing and trade. Although traditional trade fairs (aside from Kivgiq in Barrow) no longer take place, Kaktovik and Anaktuvuk Pass maintain a community-to-community relationship by which Kaktovik sends marine mammal (especially whale and seal oil) to Anaktuvuk Pass and receives inland resources (especially caribou) in exchange. Nuiqsut also participates in such exchanges, but more as a source of fish. The Kaktovik-Anaktuvuk Pass relationship is also evidenced by intermarriage between members of the two communities and by the fact that some of the founding members of Anaktuvuk Pass spent time as youth on the Beaufort Sea coastline near Kaktovik (NSB 1980).

All North Slope communities share common ancestry because of the past demographic history of the North Slope. Nuiqsut and Anaktuvuk Pass demonstrate this to an even greater degree due to their settlement histories – both were settled by those with a special attachment to the inland area. Several families have lived both in Nuiqsut and Anaktuvuk Pass at various times.

3.3.4 Land Ownership, Use, and Management

Three important aspects of land use affect development of the Project: general ownership and therefore jurisdiction in the Project area, existing land and water uses of the Project area, and land use regulations and management plans that apply to activities in the Project area. For the purposes of land ownership use and management, the area of influence is defined by the Refuge to the east, the offshore of the barrier islands to the north, Prudhoe Bay to the west, and the foothills of the Brooks Range to the south.

3.3.4.1 Land Ownership

Major land owners on the North Slope of Alaska include the State of Alaska, the federal government, the NSB, Alaska Native regional and village corporations, and Native allottees.

State Lands and Waters

As part of Statehood, the State of Alaska was entitled to select land from the federal government as an economic base for the state, following specific guidelines (ADNR 2008). Most of the Point Thomson area west of the Refuge is patented to the state (Figure 3-46). The ADNR has administrative jurisdiction over the state lands (including tidelands, submerged lands within 3 miles [4.8 kilometers] of the coast, and barrier islands) and state waters (including offshore waters within 3 miles [4.8 kilometers] of the coast, fresh water 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 subject to the lease. The surface estate is reserved by the state, and such reservation allows for the issuance of road and pipeline ROW to the extent that such ROWs do not interfere with the rights of the underlying mineral owner. The Badami Development, which would connect to the Project export pipeline, is located on state-owned lands.

Federal Lands

Federal lands are located to the east and south of the Project, and also include a small parcel at Bullen Point north of the Project export pipeline route. Lands east and south of the Project are part of the Refuge, and are under the jurisdiction of the USDOI, USFWS. With the exception of conveyed Alaska Native corporation and Alaska Native allotment owned lands within the Refuge, the USFWS has jurisdiction over the surface and subsurface estate.

Bullen Point is located west of the proposed West Pad, approximately midway to the Badami development facilities. Bullen Point is a former Distant Early Warning Facility that has been selected by the State of Alaska under its Statehood entitlement, but conveyance to the state is subject to resolving issues associated with contamination (ADNR 2009).

Federal waters/submerged lands are located 3 miles offshore of the coastline, including barrier islands. They are under the administrative jurisdiction of the USDOI, MMS.

NSB (Municipal) Lands

The Alaska Statehood Act entitled municipal governments to select lands under certain guidelines. The NSB has selected lands under its municipal entitlement within the Project area, in the vicinity of Project facilities. This selection has not yet been adjudicated

ANCSA Corporation Lands

The ANCSA of 1971 created for-profit regional and village Alaska Native Corporations. Under Section 12(a) and 12(b), these corporations are entitled to select surface and subsurface lands from the federal government; the surface acreage entitlement for village corporations was based on shareholder enrollment at the time of ANCSA; subsurface acreage entitlement for the regional corporation generally correlates to the surface acreage of its village corporations. The ASRC is the ANCSA regional Alaska Native Corporation for the North Slope. The two nearest communities with ANCSA village Alaska Native Corporations are Kaktovik (Kaktovik Inupiat Corporation) and Nuiqsut (Kuukpik Corporation). There are no conveyed or selected but un-adjudicated Alaska Native corporation lands in the Project area.

Native Allotments

A Native allotment is a parcel of land, containing 160 acres or less, that can be conveyed to an Alaska Native based on that individual’s use and occupancy of the land under the authority of the Native Allotment Act, 17 May 1906 (43 USC 270-1), as amended August 1956, and repealed by the ANCSA of 18 December 1971 (43 USC 1617) (USC 2003). The Inupiat Community of the Arctic Slope (ICAS) is the regional tribal governmental entity that assists local individuals with allotment issues. Table 3-41 and Figure 3-46 show the Native allotments that have been applied for and those adjudicated in the general Point Thomson area. In some cases, the original allottee has passed away, and conveyance or resolution of ownership to potential heirs has not yet been resolved.

There are no Native allotments that are directly affected by development of the Project. Within the Refuge, the federal government is processing conveyances of 25 applications, involving 34 parcels for Native allotments. These applications cover approximately 2,315 acres (USDOI 1987). There is a Native allotment application on Flaxman Island (BL, 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.

TABLE 3-41: ALASKA NATIVE ALLOTMENTS IN THE VICINITY OF THE POINT THOMSON PROJECT

Alaska Native Allotment Number	Status
AKFF 017781	Pending as of 2009
AKFF018780A	Pending as of 2007
AKFF018780B	Issued 1994
AKFF 012053	Issued 1999
AKFF 014632A	Issued 2005

Notes:
Source: Inupiat Community of the Arctic Slope

3.3.4.2 Land and Water Use

Residents of the North Slope have used Point Thomson for thousands of years. Traditional land use of the Project area is discussed in Section 3.3.3. This includes traditional camps on Flaxman Island and other areas along the coastline. Historic and current land and water use of the Project area includes oil and gas exploration, traditional and subsistence use by North Slope residents from several communities (see Section 3.3.3), scientific research and surveys, and summer recreation uses in the Refuge, that are primarily along the Canning River.

The area was originally leased for oil and gas exploration in 1970s. Activities associated with exploration for oil and gas have occurred intermittently in the area since that time, including development of the Badami Development Unit and exploration drilling at Point Thomson and adjacent areas. ExxonMobil currently is conducting permitted drilling activities on the Central Pad of the Project; similarly, activities are currently taking place to assess options for remediation of some of the previous exploration sites in the Project area.

Scientific research and surveys have occurred both onshore and offshore in the Project area. These activities have been associated with potential oil and gas development, and research associated with management of the Refuge.

Occasional summer recreation use occurs in the nearshore waters inshore of the barrier islands and along the Canning River on the western edge of the Refuge. A very small number of sea kayakers and other classes of boats traverse the coast off Point Thomson. The Canning River is floated each year by a limited number of rafts, kayaks, and canoes (see Section 3.3.6, Recreation).

3.3.4.3 Land Management and Regulations

State Lands

Alaska Statutes govern the disposal of interest, or use, of state lands and waters within the Project area, including mineral interests such as development of oil and gas resources. Oil and gas activities on state lands are subject to a number of guidelines and approvals from ADNR. An oil and gas lease grants the lessee the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances (ADNR 2008). However, a Plan of Operations must be approved for before any operations may be undertaken on the leased area. ExxonMobil drilling operations are being conduced under an approved Plan of Operations. Other major state approvals associated with the Project include a Pipeline ROW for the Project export pipeline, a permit to Appropriate and Certificate of Appropriation of Water, and a Materials Sales Contract.

The Project is within the coastal zone and subject to review under the Alaska Coastal Management Program (ACMP) and the NSB Coastal Management Plan. The review will determine if the Project is consistent with the standards of the ACMP, and determine whether any permit terms are required before approval.

Federal Lands

The original Arctic National Wildlife Range was established in 1960, and in 1980 was modified under the ANILCA, which renamed the Refuge and designated much of it as wilderness. The Refuge is managed under a Comprehensive Conservation Plan that was written in 1988 (USFWS 1988). The Coastal Plain area of the Refuge adjacent to the Project area has been designated as the 1002 Study Area; Section 1002 of ANILCA requires that studies be performed to provide information to Congress, including a comprehensive inventory and assessment of fish and wildlife resources, an analysis of potential impacts of oil and gas development on these resources, and a delineation of the extent and amount of potential petroleum resources. The USFWS manages the 1002 Study Area as a Minimal Management area, directed at maintaining existing conditions of areas that have high fish and wildlife values or other resource values.

Under Section 1003 of ANLICA, Congress has declared that "production of oil and gas from the Arctic National Wildlife Refuge is prohibited and no leasing or other development leading to the production of oil and gas from the [Refuge] will be undertaken until authorized by an Act of Congress" (USFWS 2009b).

NSB Lands

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

The NSB Coastal Management Plan and 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 NSB coastal management policies and the standards of the ACMP. The NSB Coastal Management Program is being revised and will be subject to approval by the State of Alaska.

Native Allotments

Activities proposed in a State-approved Plan of Operations must comply with applicable federal law governing Native allotments and must not unreasonably diminish the use or enjoyment of lands within a Native allotment (ADNR 2008). Before entering onto lands subject to a pending or approved Native allotment, lessees must contact the BIA and BLM and obtain approval to enter.

3.3.5 Transportation

3.3.5.1 Affected Environment

The transportation of equipment, personnel, materials, and supplies for the construction, operation, and maintenance of the Project could affect the existing transportation systems. Materials coming to the site could be transported by marine barge, by airplane to the proposed airstrip, or trucked up the Dalton Highway to Prudhoe Bay. Trucks would travel by road from Prudhoe Bay to Endicott, and then to the Project site along the coast on winter ice roads.

Marine Transportation Systems

Many of the supplies and equipment bound for the Project site could pass through the port of Anchorage, and possibly the ports of Seward, Whittier, and Valdez, and then to Prudhoe Bay via truck. Supplies and equipment will be transported from Prudhoe Bay to the Project site either by barge or on a winter ice road. The most used docking facility at Prudhoe Bay is the West Dock located on the west side of Prudhoe Bay and operated by BPXA. East Dock, located on the east side of Prudhoe Bay, is used occasionally for barging activities. A third dock facility at Oliktok Point, 45 miles west of Prudhoe Bay, is used for the Kuparuk oil field and operated by ConocoPhillips Alaska, Inc. Alaska Clean Seas currently provides spill response for Prudhoe Bay, Kuparuk, and Point Thomson marine facilities. A permanent spill response boat ramp will be constructed at Point Thomson for Alaska Clean Seas response units. Navigation between docking facilities along the Arctic coast is accomplished by onshore navigation aids; navigation oversight by the U.S. Coast Guard (USCG) is not required (Warr 2009). Emergency rescue is provided by the USCG, North Slope Search and Rescue, and the Barrow Good Samaritans (Warr 2009). The USCG is planning to increase its presence at Prudhoe Bay and plans to construct a permanent facility there (Warr 2009).

Local Barging Operations along Arctic Coast

Arctic coastal villages depend on summer barges to deliver materials and fuel during the brief barging season when the Arctic coast is ice-free. Kaktovik typically receives about five barge deliveries during each summer (Setterquist 2009). Crowley Maritime Corporation and Bowhead Transport Company provide local barge service out of West Dock using shallow-draft, landing-craft-type barges that can lower a front gate and offload directly onto the beach. Transport of lightweight material and fuel between Prudhoe Bay and the Project site is anticipated to be accomplished using this type of shallow-draft barge (WorleyParsons 2009).

Annual barge activities at West Dock consist of offloading materials and production modules bound for various North Slope oil fields, and loading fuel and supplies onto lightweight local barges bound for delivery to Point Thomson and Kaktovik. Dockhead 2 and Dockhead 3 are sheet pile bulkhead walls that larger barges dock against to offload large production modules, equipment, and supplies. Landing-craft-type barges also load and offload at Dockhead 2 and Dockhead 3. BPXA dredges sediment annually to a depth of 8 feet at Dockhead 2 and Dockhead 3. These dredging activities are permitted under U.S. Army Corps of Engineers (USACE) Permit No. POA-1979-291-00.

Sealift Barging Operations from Anchorage and Outside Alaska

Sealift operations that transport materials and large production modules by barge from Anchorage and ports outside Alaska takes place annually during the late summer season when the Arctic coast is ice-free, between mid-July and the first of October. These barges travel through the Bering Sea and across the top of Alaska, or occasionally travel from Hay River, Northwest Territory, Canada, down the Mackenzie River. Sealift barges offload materials at Dockhead 2 and Dockhead 3 at West Dock. A temporary docking facility is planned for the Project site that would consist of three 400-foot-long barges paced end-to-end. The barge closest to the beach would be sunk onto the ocean floor, after dredging of the ocean floor beneath it to the required depth. The second and third barges would abut the first barge to form a dock that will extend out far enough for sealift barges to dock.

Aviation Transportation Systems

The Prudhoe Bay industrial complex is served by the Deadhorse Airport and a privately-owned runway at Prudhoe Bay oil facilities operated by BPXA. Additional airstrips include Kaktovik, Nuiqsut, Kuparuk, and Barter Island airstrips. The Deadhorse Airport has a 6,500-foot-long by 150-foot-wide paved runway that currently serves approximately 19,600 aircraft per year, or 54 per day. The air traffic consists of 18 percent Air Carriers, 28 percent Air Taxi Services, 23 percent Local airplanes, and 31 percent Other. (FAA Airport Master Record 2008). Commercial cargo service is provided into Deadhorse by Northern Air Cargo; passenger service is provided by Alaska Airlines and Frontier Flying Service. The airport can accommodate aircraft up to the size of a Boeing 737. The airstrip at Kaktovik is the Bullen Point Air Force Station (also known as the Bullen Point SRRS) with a gravel runway 3,520 feet long by 100 feet wide without tower control, as well as a 160-foot by 150-foot helipad. Nuiqsut has a 4,343-foot by 90-foot public gravel airstrip not controlled by a tower, as well as an uncontrolled 3,500-foot by 170-foot airstrip owned by ConocoPhillips Alaska, Inc., and two helipads owned by Pioneer Natural

Resources Alaska, Inc., one 50 feet square and the other 65 feet square. The facilities in Kuparuk include a 6,000-foot by 130-foot airstrip with no control tower and a 75-foot by 75-foot gravel helipad, both owned by ConocoPhillips Alaska, Inc. The Barter Island airstrip is a 4,820-foot by 100-foot gravel airstrip currently in poor condition. Improvements are planned in the foreseeable future to either relocate the runway or build it up to be above the 100-year flood elevation.

Shared Services Aviation provides passenger transport of workers for BPXA and ConocoPhillips to the Prudhoe Bay and the Kuparuk airstrips. There is also a state-owned airport with an asphalt runway in Barrow, which is a transportation hub for several villages on the North Slope, and gravel airstrips located in Nuiqsut and Kaktovik. Scheduled air service is provided between Anchorage/Fairbanks and destinations of Deadhorse, Barrow, Anaktuvuk Pass, and Kaktovik. Scheduled service is also provided between North Slope communities, primarily by single- and twin-engine aircraft. The Project would also include the construction of a 5,000-foot by 175-foot gravel airstrip, most frequently used for crew changes and supplies. The airstrip would be able to accommodate a fully loaded Hercules C-130.

Highway Transportation Systems

Materials, small modules, equipment, and supplies would be transported from Fairbanks to the North Slope using the James Dalton Highway (Haul Road or Dalton Highway), which is the highway system most likely to be affected by the Project. The Dalton Highway is the only ground transportation connection between Prudhoe Bay (Deadhorse) and Fairbanks. The Parks, Glenn, and Richardson highways connect Fairbanks to Anchorage. Ice roads extend the road system to remote facilities and exploratory well sites during winter months. Ice roads are constructed over tundra or sea ice in early January with built-up layers of ice and remain operational into April. Ice roads will be required for three construction seasons for the Project (WorleyParsons 2009). The route from Deadhorse would travel east on an ice road across the Sagavanirktok River to Endicott Road, then northeast on Endicott Road to the coast, then along the coast on a winter ice road to the Project location (WorleyParsons 2009). The ice road between Deadhorse and Endicott Road will allow Point Thomson truck traffic to avoid using the main Prudhoe Bay oil field roads.

The Elliot Highway is paved between Fairbanks and the junction with the Dalton Highway, 68 miles to the north of Fairbanks. The Dalton Highway extends north 415 miles to Deadhorse from its junction with the Elliot Highway at Livengood through virtually unpopulated country. The highway is maintained by the State of Alaska Department of Transportation and Public Facilities (ADOT&PF). Emergency response is provided as needed by security emergency responder personnel stationed at Alyeska Pipeline Service Company pump stations adjacent to the highway. The first 49 miles of the Dalton Highway are paved; the pavement ends just south of the Yukon River. The remainder of the road to Prudhoe Bay is a 28-foot-wide, two-lane gravel road with periodic turnouts. ADOT&PF currently provides routine maintenance as needed, but the highway would require substantial upgrades if a natural gas pipeline goes to construction. Traffic along the Dalton Highway is made up mostly of trucks transporting supplies to the Prudhoe Bay oil fields, but is also increasingly used by the public and tour operations. The public can travel as far north as the security gate at Deadhorse. Roads beyond the security gate are privately owned and maintained by BPXA Annual Average Daily Traffic (AADT) for the Dalton Highway has steadily increased from 210 vehicles a day in 2006, to 280 vehicles a day in 2007, and to 290 vehicles a day in 2008 (ADOT&PF 2009).

The existing private roadway structure beyond Deadhorse is maintained by private oil companies. Roads in the Prudhoe Bay oil field are maintained by BPXA Spine Road extends 45 miles to the west of Prudhoe Bay to the Kuparuk oil field, operated and maintained by ConocoPhillips Alaska, Inc. Endicott Road extends 12 miles east of Prudhoe Bay to the Endicott oil field, operated and maintained by BPXA. BPXA maintains a volunteer fire unit and Emergency Medical Technician (EMT) response unit that serve the Prudhoe Bay area (Hegna 2009). Alaska Clean Seas provides spill response services within the Prudhoe Bay oil fields.

3.3.6 Recreation

3.3.6.1 Recreation Use of the Refuge

Recreation activities occur throughout the North Slope, but only in limited parts of the Project area. While some developed recreation services are provided in the region, the area is known for opportunities for remote, dispersed recreation activities. The area is also known for the recreation setting, with challenging access, outstanding opportunities for solitude, and vast, unaltered landscapes.

Recreation use statistics are not available for the region as a whole. However, federal agencies make attempts to track recreation use numbers. In the vicinity of the Project area, the USFWS estimates 1,200–1,500 visitors travel to the Refuge annually (USFWS 2009). While there are annual fluctuations in estimates, numbers have remained in this range for approximately 20 years. Tourism to the North Slope, and the Refuge in particular, tends to spike when Congress is considering legislation that could affect the status of the 1002 Study Area.

Developed Recreation

Services associated with developed recreation activities are limited, such as guided tours. Available services are centered in North Slope communities, such as Barrow, Deadhorse, and Kaktovik, and transportation hub communities such as Fairbanks. Services include sightseeing flights, wildlife viewing tours, cultural tours, and guided trips.

Developed recreation facilities, such as campgrounds, trails, picnic areas, public use cabins, public restrooms, potable public water sources, and public boat launches are not available in the region.

Dispersed Recreation

Dispersed recreation activities are typical in the region. Activities such as sport hunting, river floating (e.g. rafting, kayaking), and backpacking are common. Other recreation activities include viewing scenery, wildlife viewing, camping, sport fishing, backcountry hiking, recreational gold mining, and photography. Wildlife important for recreation viewing and photography include moose, wolf, bear, caribou, Dall sheep, Arctic fox, red fox, wolverine, muskox, waterfowl, shorebirds, passerines, falcons, and golden eagles.

These dispersed recreation activities occur in low densities, without support facilities Communities such as Arctic Village and Anaktuvuk Pass act gateways to the Refuge and Gates of the Arctic National Park and Preserve; many backcountry trips originate and/or terminate in these communities.

Public lands in the Refuge, the NPR-A, and along the Dalton Highway are the primary public recreation use areas. The BLM and the ADOT&PF 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).

Recreation activities in the vicinity of the project area include floating the Canning River (east of the Project area) as well as boating in the nearshore waters of the Beaufort Sea. A very small number of sea kayakers and other classes of boats traverse the coast off Point Thomson (Clough et al. 1987; USFWS 1993b; BPXA 1995).

Recreation Setting

Access

As identified in Section 3.4.2.7, Transportation, access to the region is limited. Recreationists can drive or fly to Deadhorse, but can only access the Arctic Ocean and Prudhoe Bay oil fields 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 and access is not developed. Air taxi operators also offer transportation services for recreationists, providing access to remote locations throughout the North Slope, including the Refuge and NPR-A.

Much of the recreation use in Refuge is centered around the river corridors, as they facilitate transportation through the vast area. The Kongakut (east of Kaktovik), Hulahula (south of Kaktovik), Canning (west of Kaktovik, in the vicinity of Point Thomson), Ivishak (west of Point Thomson), and Sagavanirktok (west of Point Thomson) rivers are used for river travel (USFWS 1988). Travel in the area is generally considered primitive; that is, non-motorized forms of transportation are generally used for cross-country travel, such as hiking, rafting, and dog mushing.

Opportunities for Solitude

The Refuge, including the Mollie Beattie Wilderness and the 1002 Study Area, offer outstanding opportunities for solitude, or opportunities to be removed from the sights, sounds, and presence of humans and human developments. There are typically few, if any, social encounters for visitors to the area. With the vast land area and the low number of recreationists, use is generally well dispersed. Broader infringements upon solitude have generally included sights and sounds of aircraft, as well as occasional sounds of industrial activities related to oil and gas exploration or operations.

Vast Landscapes

The vast landscapes influence the amount and type of recreation that occurs in the area. This setting offers opportunities for visitors to interact with nature, in isolation from others. There is little vegetation alteration due to human activities; the area is generally naturally appearing, with little evidence of prior human use. The area, in general, does not contain signs, trails, roads, or facilities to accommodate visitors. Development in the area is centered in Deadhorse, Kaktovik, and Prudhoe Bay. With the exception of the Badami facility and the Bullen Point DEW line site, there is little development between Deadhorse/Prudhoe Bay and Kaktovik.

Since the area rivers serve as recreation travel corridors, they also serve as the primary landscape viewpoints. Of the rivers that are used for recreation activities, the Canning River is the closest to the Project site. This river is braided, with a moderate gradient. There are many opportunities for hiking ridges and side canyons. A trip log (Alaska Outdoors Supersite 2009) from a site visit to the Canning River, that included federal and state agency staff, described the scenery as the most outstanding feature of the river. The river setting was described as "intimate… where the mountains rise up within easy walking distance from much of the river".

The Canning River passes through a very interesting as well as scenic geologic display. The stratigraphic record revealed in the rocks of the Sadlerochit and Shublik mountains is very similar to that in the area of Prudhoe Bay oil field. Thus a traveler through this area has the opportunity to see and interpret the same rock sequence and phenomenon that is present in the petroleum bearing rocks underneath the Arctic Slope. Viewable from the river are textbook examples of structural features formed by the uplift of the mountains.

The Canning River airstrip for guided float trips is located approximately 11 miles (18 kilometers) south of the Project area.

Wilderness Values

In 1980, the Arctic National Wildlife Refuge Wilderness was designated by Congress under Public Law 96-487; the area was re-named the Mollie Beattie Wilderness in 1996 under Public Law 104-167. The 8 million acre wilderness area is managed by the USFWS as part of the Refuge. While the area is valued for many reasons, some of the wilderness values for which the area is managed include: size of the area, natural integrity, apparent naturalness, opportunities for solitude, and outstanding opportunities for primitive recreation.

The Wilderness Act (1964) requires that a wilderness be 5,000 acres in size, or "large enough to allow for its preservation and use in an unimpaired condition." The size of the Mollie Beattie Wilderness contributes to the maintenance of the other wilderness values considered, particularly opportunities for solitude and primitive recreation. The features of the vast landscape, including distance from developments, size of the area, topography, and natural vegetation, contribute to outstanding opportunities for solitude and primitive recreation. As previously mentioned, the area receives low visitation levels and use is generally well dispersed. There are few infringements upon opportunities for primitive recreation; marked trails, foot bridges, signs, cabins, and other facilities are not present in the area.

3.3.7 Visual Aesthetics

3.3.7.1 Introduction

This section describes the existing visual resources located within 30 miles of the Project. Included in this description is a discussion of landscape and atmospheric conditions, potential viewer groups, and their expected sensitivity to changes in visual resource conditions.

Regulatory Framework

There are no local, state, or federal regulations applicable to visual resources within the study area. The western border of the Refuge is located approximately 1 mile from the East Well Pad. The Arctic National Wildlife Refuge Comprehensive Plan indicates a management direction that maintains the scenic values of the Refuge and minimizes the visual impact of development (USFWS 1988).

3.3.7.2 Affected Environment

Regional Context

The ACP is the northernmost ecoregion in Alaska. It is bounded on the north and west by the Arctic Ocean, and extends eastward almost to the boundary with the Yukon Territory, Canada. The landscape is characterized as a treeless, low-relief landscape that rises gradually from sea level to the foothills of the Brooks Range located to the south. Topography within the ACP is limited to cone-shaped hills and mounds of tundra, known as pingos, that reach elevations of approximately 100 feet.

During the winter months (September–May), the terrain is frozen and covered with snow and ice. At this time, the nearshore environment freezes, creating nearly contiguous ice cover that extends from the mainland to the barrier islands. The Arctic winter includes 56 days of darkness in which the sun does not rise above the horizon. In the summer months (June–August), the terrestrial environment thaws, creating extensive wetlands, ponds, and rivers and exposing low-lying vegetation. Ice cover in the nearshore marine environment thaws and the Beaufort Sea again separates mainland Alaska from the barrier islands, located to the north. These islands are characterized as low-elevation land masses, consisting mostly of sand and gravel, with sparse vegetation.

Physical characteristics of the region combine to create several unusual visual occurrences, including the northern lights (aurora borealis), light intensification, arctic haze, and fata morganas (also known as mirages). Northern lights occur frequently during winter and are manifested in a variety of forms. Displays include a spectrum of colors including greens, pinks, and yellows which appear as a fog-like glow or vertical moving steamers with glowing, expanding curves. Light intensification occurs when ice crystals are suspended in the air and cause a light source, such as a flare, to appear brightly lit. From the ground, suspended ice crystals appear as fog. If light travels through the ice crystals, the light intensifies, making its source visible from a greater distance. Arctic haze, believed to originate from long-range transport of pollutants, occurs mainly during winter and spring and can reduce visibility from 50 miles to less than 5 miles. Fata morganas, or mirages, are the result of unusually refracted light caused by an almost contiguous temperature inversion in the polar Arctic. Consequently, distant objects and features are distorted and appear much larger and brighter than they actually are. Fata morganas are most noticeable when looking seaward during the summer months.

The Refuge is the only scenic resource of national significance present within this area. The Refuge is undeveloped, and is known for its dramatic scenic quality. The remoteness and expansive views from the Brooks Range attract backpackers, photographers, and hunters from around the world. The Refuge has three federally designated Wild and Scenic Rivers within its borders: the upper Sheenjek, Ivishak, and Wind rivers. These rivers each have classifications of Wild and Scenic because of their high scenic, recreational, and wildlife values. Although no federally designated Wild and Scenic Rivers are present in the affected environment, the Canning River, located approximately 20 miles from the proposed facility, is known for its scenic and recreational value.

Study Area

The Project is located on the ACP, and occupies lands located inland and along the shoreline of the Beaufort Sea (Figure 3-47). The barrier islands (Challenge, Alaska, Maquire, Duchess, North Star, Mary Sachs, and Flaxman islands) are located within 5 miles of the shoreline, due north of the Project area. Upland areas are characterized by shallow topography, low-lying vegetation, and numerous waterways and ponds that drain to the Beaufort Sea. The Staines River and the Refuge form the eastern border of the Project area. Portions of the Refuge located within the study area are characterized by the broad, braided channels of the Staines and Canning rivers.

In addition to existing development at the Central Pad at Point Thomson, several onshore oil and gas fields with developed well production facilities are located in the Prudhoe Bay area west of the Project area. These facilities include gravel pads, reserve pits, buildings, gravel roads, pipelines, snow fences, heavy equipment, drilling rigs, flares, lights, and power lines (USACE 1999a).

Viewer Groups

Viewer groups, or receptors, located within 30 miles of the proposed facility include local residents, recreators, and workers. Viewer groups are defined as assemblages of individuals who may view the study area from the same vantage point, for a similar duration, and with shared sensitivity. Viewer sensitivity is defined as both the viewers' concern for scenic quality and their perception of change in the visual resources (Federal Highway Administration [FHWA] 1981). Viewer sensitivity is typically lower where prior development has occurred, and higher in remote and scenic areas, where viewer groups expect to see an intact landscape. The five predominant viewer groups present in the study area are described below.

Local Residents

Nuiqsut and Kaktovik are the only two communities located within 100 miles of the study area. Nuiqsut is located on the Colville River, 18 miles upriver from the Beaufort Sea and approximately 92 miles from the west end of the export pipeline. Kaktovik is located on the north shore of Barter Island, between the Okpilak and Jago rivers, approximately 57 miles east of the East Pad. Members of both communities use lands located within the study area, including the Project site and waters located directly offshore, for subsistence harvesting activities in the summer and fall. The local resident viewer group is expected to have exposure to views of the study area during day- and night-time hours. Because members of these communities are accustomed to viewing this landscape in an intact and undeveloped form, they are expected to have high viewer sensitivity. Refer to Section 3.3.3 for additional information about subsistence activities in the study area.

Recreators

The primary recreation activities occurring in the vicinity of the Project occur on the nearby Refuge, and include camping, scenic viewing, sport fishing, hiking, recreational gold mining, photography, and river rafting on the Canning River. Access to the area is limited to travel by air or water, and no designated camping sites or recreation facilities exist. Recreators are most often engaged in multi-day trips, and this viewer group has potential to view the study area during day- and night-time hours. Because individuals visiting this area for recreational purposes anticipate pristine views and a remote setting, they are expected to have high viewer sensitivity.

Facility Employees

The construction workforce is expected to peak at approximately 380 when ice road construction, pipeline construction, and civil construction works are occurring at the same time. The Project will require an operations workforce of approximately 80 people. Additional workers will be required during drilling or workover operations and during special work programs (e.g., planned and emergency maintenance operations). Facility employees are generally engaged in industrial and operational activities. Because employees of all remote facilities reside on site, they are expected to have day- and night-time views of the study area. Employees are considered to have low viewer sensitivity because they are accustomed to industrial facilities and are not engaged in activities that focus on observation or appreciation of the natural environment.

USFWS Employees

The USFWS maintains a temporary camp located in the Refuge, approximately 6 miles from the East Pad, and approximately 19 miles from the Central Processing Facility (CPF). This camp is used typically during the summer months. The USFWS employee viewer group is expected to have views of the study area during day- and night-time hours. Visitors to the USFWS Temporary Camp are expected to have high viewer sensitivity because they are engaged in activities that focus on the observation or appreciation of the natural environment.

Arctic Tourists

Arctic tourism, which includes travel to the northern tip of Alaska by cruise ship, is becoming increasingly popular. A small number of cruise ships visit the region each summer. Tourists visiting this region by cruise ship would view the Project area primarily from the ship. The arctic tourist viewer group is expected to have moderate sensitivity because, whereas they may be seeking a remote recreation experience, they are assumed to be more accustomed to developed shorelines and larger ports-of-call.

3.3.8 Environmental Justice

This section addresses environmental justice and is organized differently than other resource sections in this ER. The analysis presents a brief description of the policies and guidance related to environmental justice, an assessment of how environmental justice applies in the region, and the types of effects the project may have in terms of environmental justice.

Environmental justice became a focus following President Clinton's issuance of Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. The Executive Order requires federal agencies to develop strategies to address environmental justice concerns in their approach to their regular operations. EPA defines environmental justice as:

> *"The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."*

Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs or policies. EPA's guidance on incorporating environmental justice in NEPA analyses notes that "fair treatment" calls for identifying disproportionately high and adverse effects and identifying alternatives that could mitigate those impacts (EPA 1998).

3.3.8.1 Regional Overview

Section 3.3.1, Socioeconomics, provided an overview of the NSB and the two nearest communities to the Project area, Kaktovik and Nuiqsut. The NSB and the two communities are considered a special segment of the population whose socioeconomic characteristics and life style and geographic ties to the region warrant additional analysis to evaluate the potential for disproportionably high and adverse effects to the local population.

The North Slope includes two relatively distinct populations: local residents who are predominately indigenous Iñupiat Natives, and the oil and gas industry workforces, who rotate on a regular schedule and are predominantly temporary worker/residents in the region. Local residents of the region form the primary social structure and the local economy. As temporary residents, the oil and gas industry workers have minimal participation in the local economy, and their needs for all services are provided by industry. Revenue from oil and gas property tax contributes to NSB jobs, services, and infrastructure, and industry employs residents directly and indirectly through service contracts with Alaska Native corporation subsidiaries.

The North Slope, as a regional economy, is not highly diversified and is more sensitive to internal and external economic changes. Based on the per capita income data, the North Slope population might not qualify as a low-income community for environmental justice consideration.

However, personal income data alone do not address the question of overall economic well-being. Within individual communities, job opportunities are limited and unemployment is higher than the state average. Many North Slope residents rely on subsistence activities, which do not figure in the income data. In addition to income and economic thresholds, environmental justice considerations are also triggered by the race/ethnicity threshold found in the Inupiat communities of the North Slope.

3.3.8.2 North Slope Borough Issues of Concern

North Slope Inupiat concerns regarding oil and gas development have been documented in recent EIS, such as the NPR-A Supplement EIS (BLM 2008). As indicated consultation for this project, concerns and benefits for an environmental justice evaluation may include:

- Opportunities for employment and income that also support traditional subsistence activities;
- Revenue that supports and improves health and education services;
- Access to lands and waters for traditional uses and sense of place;
- The presence of a facility mid-way between Kaktovik and Prudhoe Bay that can be utilized by local residents for emergencies when traveling through the area; and
- Concern about contaminants entering the environment and the subsistence food chain on which they rely.

Residents of the NSB and the communities of Kaktovik and Nuiqsut rely on subsistence as a food source and as a cultural and social way of life. Within the Arctic communities, these cultural ties are reflected in social traditions that accompany hunting, gathering, and harvesting. Currently, communities are seeking to balance between the influence of new economic opportunities, such as oil and gas development and eco-tourism, and a way of life that provides sustainable methods to care for their families and surrounding environment. Employment at the Project site may be temporary or permanent, depending on the job and service provided. With Kaktovik being the closest community to the Project (approximately 60 miles to the east), both benefits and concerns regarding Project development will be the center of an environmental justice analysis.

Section 4.3.8 assesses the Project's potential impacts on the NSB and communities of Kaktovik and Nuiqsut.

4.0 ENVIRONMENTAL CONSEQUENCES

This chapter assesses the potential direct and indirect effects of the proposed Point Thomson Project (hereinafter the Project) on the affected environment, as described in Chapter 3. The majority of the sections contained within this chapter assess these potential effects per the Project's three phases: drilling, construction, and operations. For purposes of this analysis, direct and indirect effects are defined as follows:

- **Direct Effects** – caused by the action and occur at the same time and place.
- **Indirect Effects** – caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.

Resources were categorized as follows for both direct and indirect effects:

- **None** – Effects on subject resources may occur as a result of project activities, but are not measurable.
- **Minor** – Effects that have a measurable impact, and individually may or may not require avoidance or minimization to mitigate that effect.
- **Moderate** – Effects that have a measurable impact and will require avoidance or minimization to mitigate that effect.
- **Major** – Major effects are to be considered both in context and intensity. These effects have a measurable effect and, individually or cumulatively, require avoidance or minimization to mitigate the impact.

Where applicable, potential effects on resources were quantified using the following criteria:

- **Intensity** – Refers to severity of the impact (low, medium, high).
- **Duration** – Refers to the anticipated length of the impact (temporary, long-term, permanent).
- **Scope or Magnitude** – Refers to the geographic boundaries, populations, or regions potentially affected (local, regional, national).
- **Context** – Refers to the resources, ecosystems, or human communities affected (common, important, unique).

This analysis of potential effect does not include dismantle, remove, and restore (DR&R). The Project's life span is not yet determined, and DR&R requirements that will be in effect are unknown at this time.

4.1 PHYSICAL ENVIRONMENT

4.1.1 Meteorology and Air Quality

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.1.1. Consequences are presented for drilling, construction, and operations.

4.1.1.1 Direct and Indirect Effects to Meteorology

Generally, meteorology is affected by global complex climatic systems that originate from conditions that are not a direct result of the local environment. However, changes to the local meteorology may occur in a project area. For example, local structures, such as buildings that will be constructed for the Project, may interrupt wind-flow patterns. Ambient wind conditions may be affected by structures that create a wake, where wind is forced downward and becomes entrapped on the leeward sides of buildings. Also, exhaust from Project equipment will cause thermal updrafts that will affect local wind conditions. Temperatures may be affected slightly from heat generated by the Project buildings and by equipment, such as turbines and heaters. These localized effects to meteorology will not persist outside of the Project area and will not have a measurable effect on a nearby resource.

The indirect effects on meteorology that may be caused by the Project include a possible effect on climate change from the contribution of greenhouse gases (GHG) emitted by equipment associated with the Project. The effects to climate and meteorology from GHG emissions from the Project are unclear, because the contribution of anthropogenic factors to climate change have not been determined and emissions are a negligible contribution to the amount of GHG emissions worldwide. Furthermore, any observed and predicted changes are the result of GHG emissions on a global scale and not a local or regional scale. A discussion of GHG emissions and the potential climate change associated with the Project is presented in Section 4.1.5.

4.1.1.2 Direct Effects to Air Quality

Direct effects to air quality are those effects that are caused by the Project and occur at the same time and place. For the Project, these effects may result from the release of pollutant emissions into the atmosphere that occur as a result of the drilling, construction, and operational phases associated with the Project. Air pollutant emissions from these activities are under the jurisdiction of Alaska Department of Environmental Conservation (ADEC) and U.S. Environmental Protection Agency (EPA), which regulate air quality under the requirements of 18 AAC 50, 40 Code of Federal Regulation (CFR) 50, 40 CFR 52, 40 CFR 60, and 40 CFR 63, among numerous other statutes and regulations.

Projects that will have an effect on air quality must meet the primary and secondary National Ambient Air Quality Standards (NAAQS) and the Alaska Ambient Air Quality Standards (AAAQS) for nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particles or particulates of aerodynamic diameter of 10 micrometers of less (PM_{10}), fine particles or particulates that are 2.5 micrometers or less in diameter ($PM_{2.5}$), carbon monoxide (CO), lead, and ozone (O_3). These standards are designed to protect the public from any known or anticipated adverse effects associated with the presence of such air pollutants in the ambient air. Under Section 109 of the Clean Air Act (CAA), primary ambient air quality standards are prescribed by the EPA and are established to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards are prescribed by the EPA to protect the public welfare, including protection against decreased visibility and any damage that may occur to plants, animals, or property. ADEC has either adopted these primary and secondary standards or has included additional standards. Table 4-1 and Table 4-2 include summaries of the NAAQS and AAAQS, respectively.

ADEC has also established Class II increment limits for NO_2, SO_2, and PM_{10} as part of the state prevention of significant deterioration (PSD) air permitting program. Increment may be defined as the increase in ambient concentration of a pollutant at some location over the ambient concentration of the pollutant that occurred in an established baseline year. In areas where air quality meets the levels of the NAAQS, such as the North Slope, PSD increment limits are established to limit increases in air pollution for a project and limit the degradation of existing air quality of the region. Table 4-3 includes a summary of the PSD Class II increment limits.

As part of the air permitting process, ADEC will review the potential effects from air pollutant emissions that will result from a project. ADEC has the discretion to require a modeling demonstration for any phase of a project to determine if the air pollutant emissions from the Project are deemed to have the potential to have a significant effect on the area. Air quality models such as the EPA-approved AERMOD model use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Meteorological data and information regarding emission rates for equipment are used in a modeling exercise to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions in the atmosphere. ADEC will only issue an air permit for a project after a demonstration with all applicable ambient air quality standards is made and the protection of public health and welfare is assured.

Drilling

Drilling activities will include reciprocating internal combustion engines, heaters, and boilers associated with the drill rig. In addition, portable and mobile equipment will also combust fossil fuels that will be used to support drilling operations. Pollutant emissions from drilling equipment will be generated from the combustion of diesel fuel that will primarily include NO_2 CO, and PM_{10} with lesser amounts of volatile organic compounds (VOC) and SO_2.

Air permits will be obtained that will authorize the activities associated with the drilling phase of the Project. A modeling exercise may be a required element of an air permit that will be used to demonstrate that the worst-case, short-term drilling emissions will not exceed emission standards. Any air permits issued will include operational requirements to ensure that emission levels remain low enough to ensure NAAQS, AAAQS, and increment standards will not be exceeded. This will ensure protection of public health and welfare in the Project area during drilling. For these reasons, emissions during drilling will not adversely impact the resources in the area including the Arctic National Wildlife Refuge (hereinafter the Refuge) and villages along the Beaufort Sea Coast, Nuiqsit, and Kaktovik.

Construction

During construction activities at the Project, emissions of criteria pollutants, including NO_2, CO, and PM_{10} will result from the combustion of fossil fuels. These emissions will be released in the exhaust of heavy equipment used in site preparation to excavate gravel, build gravel pads and an airstrip, and construct gathering lines and export pipelines. In addition, small electric power generators, heaters, and other fuel-burning equipment will contribute to emissions of criteria pollutants during construction. Dust will also likely result from the movement of gravel and from roadway traffic.

The amount of emissions from these types of equipment is small in comparison to the equipment associated with the operational stage of the Project and the potential effects to regional air quality will be minor. Because these types of emissions from construction activities do not occur for an extended duration, the effects to regional air quality will also be short-lived in the environment. Sensitive resources such as the Refuge and the rural communities of Nuiqsut and Kaktovik will not be significantly affected from pollutant emissions associated with construction activities at the Project because no long-range transport is expected to occur from these small sources of pollutant emissions. Furthermore, local meteorology for the Project area is dominated by predominant strong winds from the east that will reduce any potential effects that may occur to the nearby areas of the Refuge and Kaktovik to the east. Any episodes of dust will be limited to the short summer season when roadways and gravel pads are not frozen.

ADEC has determined that the types of equipment associated with construction generally have a small effect on air quality and do not generally require an ambient air modeling exercise for the construction phase of the Project. Consistent with ADEC Policy and Procedure Document 04.02.104, emissions from the temporary construction activities for the Project will not require a modeling demonstration, because the equipment will consist of small, close-to-the-ground equipment, such as earth-moving equipment, small electric generators, and heaters. ADEC has determined that emissions associated with construction are better managed through fuel sulfur levels rather than an ambient air modeling demonstration.

During construction, another direct effect on air quality that may be caused by the Project is reduced visibility. Visibility is reduced when sunlight encounters tiny particles in the air (e.g., dust) and the clarity and color of the air are reduced. Fugitive dust emissions that occur from road use and construction activities will have an insignificant effect on air quality. These types of emissions in the Arctic are limited to the summer months from approximately June–September, because the ground is consistently snow- and ice-covered during winter.

The Liberty Project gives a good measure of the expected effects that the Project will have on visibility. BP Exploration (Alaska), Inc. (BPXA) has conducted an analysis of visibility for the Liberty Project using the EPA-approved VISCREEN model. The VISCREEN model calculates the potential effects of a plume of specified emissions for specific transport and dispersion conditions on the basis of existing meteorology of an area. The results of the Liberty visibility modeling show noticeable effects on a limited number of days with adverse meteorological conditions (e.g., extreme high wind conditions in summer months) but no effects at all during average meteorological conditions (HCG 2007a). Given that meteorology is expected to be similar between the Liberty Project and the Project, these data show that the effects to visibility in the area of the Project will be negligible.

Any reduced visibility that may occur as a result of the Project will not significantly affect any nearby sensitive areas, such as the Refuge and the rural communities of Kaktovik and Nuiqsut. The Minerals Management Service (MMS) has collected meteorological data for the North Slope that show wind direction becomes influenced by topography and will have a tendency to parallel the longitudinal axis of the Brooks Range moving east along the Arctic coast (HCG 2007b). Wind roses developed from these data for the eastern coast of the North Slope show a wind direction primarily from the east, with a north-easterly component. Any episode of reduced visibility generated by the Project will have a minor effect with an expected short duration on the resources downwind to the west.

The Project will incorporate design features intended to mitigate the potential direct effects to air quality during construction. For example, construction activities have been scheduled to minimize overlap of projects to stagger tasks to reduce short-term effects that may result from the Project. Episodes of reduced visibility will be reduced with dust suppression activities such as watering roadways during the summer months and use of speed limits.

Operations

The operations phase of the Project will include stationary equipment such as turbines for power generation, gas compression, oil pumping, and water injection as well as reciprocating internal combustion engines, heaters, and boilers. This equipment will combust fossil fuels and will emit combustion emissions such as NO_2, CO, and SO_2. VOC emissions will result from evaporative losses from tanks, pumps, compressor seals, and valves. Safety flares may also be used to burn gas released from the production process during emergencies and equipment shutdowns.

A modeling demonstration will be completed for the operations phase of the Project after the final engineering design has been completed. An examination of the air quality modeling analysis performed for the Liberty Project provides a good measure of the expected effects that may occur for the Project during operations, because the overall pollutant emissions emitted from the Project are expected to be less than or equal to the Liberty Project. The highest predicted concentrations for NO_2, SO_2, and PM_{10} from air modeling conducted by BPXA on the basis of the proposed operation for the Liberty Project document that the concentrations of pollutants emitted will meet the NAAQS, AAAQS, and PSD Class II increment limits indicating good air quality in the region (HCG 2007a). Therefore, the air quality effects for the Project area are expected to be less than or equal to the Liberty Project and indicate that the existing good air quality in the Project area will be maintained and will not adversely affect human health or welfare. In addition, for NO_2 reduction, or if the equipment for the Project has potential emissions of other constituents at greater than 250 tons per year per pollutant, best available control technology (BACT) will be required using state-of-the-art methods, systems, techniques, and production processes to achieve the greatest reduction in air pollutants emitted. Any BACT that is required for the Project would ensure more reduction in pollutant emissions and help protect the public health and welfare.

Data have been collected for sources in the region that demonstrate projects of a scale similar to the Project will not significantly affect areas at a distance greater than 6.2 miles (10 kilometers) from the Project. For example, air quality modeling completed by BPXA for Liberty shows that the highest ambient concentrations of NO_2, SO_2, and PM_{10} are within the AAAQS and PSD increment limits and occur within 0.12 miles of the facility boundary (MMS 2002). The modeling for Liberty demonstrates that the concentrations are considerably reduced at distances greater than 0.6 mile (1 kilometer). At distances greater than 6.2 miles (10 kilometers), the emissions from Liberty are expected to have little effect on the surrounding area. Modeling studies of proposed Outer Continental Shelf (OCS) production facilities in the Beaufort Sea show that concentrations of NO_2, SO_2, and PM_{10} are within the NAAQS and PSD incremental limits, with the highest concentrations of NO_2, SO_2, and PM_{10} occurring within about 0.12 miles (200 meters) of the facility and considerably reduced values at distances greater than 0.6 mile (1 kilometer) (MMS 2001). The annual pollutant emission rates for these facilities are approximately equal to or greater than the expected annual emissions for the Project. These data demonstrate that the pollutant emissions from the Project will have no measurable effect on neighboring areas at a distance greater than 6.2 miles (10 kilometers) such as the Refuge. Furthermore, the air quality in the rural communities of Kaktovik and Nuiqsut will not be significantly affected by the Project because these villages are located at a distance of more than 60 miles and 93 miles (96 and 150 kilometers, respectively), from the Project.

TABLE 4-1: SUMMARY OF NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Period	Primary Standard	Secondary Standard	Regulatory Citation
NO_2	Annual	100 µg/m^3 (0.053 ppm)	Same as Primary	40 CFR 50.11(a) and (b)
CO	8-hour	10 µg/m^3 (9 ppm)	----	40 CFR 50.8(a)(1)
	1-hour	40 µg/m^3 (35 ppm)	----	40 CFR 50.8(a)(2)
PM_{10}	24-hour	150 µg/m^3	Same as Primary	40 CFR 50.6(a)
$PM_{2.5}$	Annual	15.0 µg/m^3	Same as Primary	40 CFR 50.13(a)
	24-hour	35 µg/m^3	Same as Primary	40 CFR 50.13(a)
O_3	8-hour	0.075 ppm (2008 standard)	Same as Primary	73 FR 16511
	8-hour [1]	0.08 ppm (1997 standard)	Same as Primary	40 CFR 50.9(a)
	1-hour	235 µg/m^3 (0.12 ppm)	Same as Primary	40 CFR 50.10(a)
SO_2	Annual	0.030 ppm	----	40 CFR 50.4(a)
	24-hour	0.14 ppm	----	40 CFR 50.4(b)
	3-hour	---	0.5 ppm	40 CFR 50.5(a)
Lead	Rolling 3-month	0.15 µg/m^3	Same as Primary	73 FR 67052
	Quarterly	1.5 µg/m^3	Same as Primary	40 CFR 50.12(a)

Notes:
[1] The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
CFR = Code of Federal Regulations
CO = carbon monoxide
EPA = U.S. Environmental Protection Agency
FR = Federal Register
NO_2 = nitrogen dioxide
O_3 = ozone
PM_{10} = particles or particulates of 10 micrometers or less
$PM_{2.5}$ = particles or particulates that are 2.5 microns or less in diameter
ppm = parts per million
SO_2 = sulfur dioxide
µg/m^3 = micrograms per cubic meter

TABLE 4-2: SUMMARY OF ALASKA AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Period	Standard	Regulatory Citation
NO_2	Annual	100 $\mu g/m^3$	18 AAC 50.010(5)
CO	8-hour	10 $\mu g/m^3$	18 AAC 50.010(3)(A)
	1-hour	40 $\mu g/m^3$	18 AAC 50.010(3)(B)
PM_{10}	Annual	50 $\mu g/m^3$	18 AAC 50.010(1)(A)
	24-hour	150 $\mu g/m^3$	18 AAC 50.010(1)(A)
O_3	1-hour	235 $\mu g/m^3$	18 AAC 50.010(4)
SO_2	Annual	80 $\mu g/m^3$	18 AAC 50.010(2)(A)
	24-hour	365 $\mu g/m^3$	18 AAC 50.010(2)(B)
	3-hour	1,300 $\mu g/m^3$	18 AAC 50.010(2)(C)
Lead	Quarterly	1.5 $\mu g/m^3$	18 AAC 50.010(6)
Reduced Sulfur	30-min	50 $\mu g/m^3$	18 AAC 50.010(7)
NH_4	8-hour	2.1 $\mu g/m^3$	18 AAC 50.010(8)

Notes:
AAC = Alaska Administrative Code
CO = carbon monoxide
NH_4 = ammonium
NO_2 = nitrogen dioxide
O_3 = ozone
PM_{10} = particles or particulates of 10 micrometers or less
SO_2 = sulfur dioxide
$\mu g/m^3$ = micrograms per cubic meter

TABLE 4-3: SUMMARY OF PREVENTION OF SIGNIFICANT DETERIORATION CLASS II INCREMENT LIMITS

Pollutant	Averaging Period	Maximum Allowable Increase	Regulatory Citation
NO_2	Annual	25 $\mu g/m^3$	18 AAC 50.020
PM_{10}	Annual	17 $\mu g/m^3$	18 AAC 50.020
	24-hour	30 $\mu g/m^3$	18 AAC 50.020
SO_2	Annual	20 $\mu g/m^3$	18 AAC 50.020
	24-hour	24 $\mu g/m^3$	18 AAC 50.020
	3-hour	512 $\mu g/m^3$	18 AAC 50.020

Notes:
AAC = Alaska Administrative Code
NO_2 = nitrogen dioxide
PM_{10} = particles or particulates of 10 micrometers or less
SO_2 = sulfur dioxide
$\mu g/m^3$ = micrograms per cubic meter

Meteorological data for the Project area suggest that any modeling demonstration for the Project will show that any effects to air quality will not occur near sensitive areas in the region, including the Refuge and the rural communities of Kaktovik and Nuiqsut. As mentioned previously, MMS has collected data that show wind direction on the eastern coast of the North Slope is primarily from the east with a north-easterly component, and wind direction in the area of the Project will have similar winds that primarily come from the east. These data, suggest that potential downwind effects from the Project would occur in areas primarily to the west with strong winds that will provide good dispersion that will not create effects on the rural community of Nuiqsut located at a far distance to the west of the Project area.

Data for the actual air pollutant emissions associated with the Prudhoe Bay industrial complex can also be examined to gauge the effects that may occur because of the Project. The Prudhoe Bay industrial complex includes numerous oil and gas production facilities, drill rig sites, and a large roadway system that is substantially larger in scale than the Project. BPXA has operated an ambient air monitoring program since 1986 that collects air pollutant data for NO_2, SO_2, O_3, and PM_{10} as part of the Prudhoe Bay Ambient Air Monitoring Program (PBAAMP). These data consistently show that the pollutant concentrations at Prudhoe Bay are below NAAQS and AAAQS. A summary of the data for the PBAAMP for 2007 is provided in Table 3-3. On the basis of these data and the fact that the Project is significantly smaller in scale than the facilities associated with the Prudhoe Bay complex, the overall ambient air pollutant concentrations because of emissions from equipment associated with the Project are expected to be below the air quality standards, such that human health and welfare will not be adversely affected by the project.

The Project will include numerous design features that will help to mitigate or reduce the potential direct effects to air quality during operations. For example, fuel gas will be burned in the power generation turbines instead of diesel fuel to reduce the effects on air quality. Storage tanks will be used with pressure/vacuum valves and/or overhead vapor recovery systems to reduce the effects on air quality that may result from the release of VOCs. Exhaust stacks for stationary combustion equipment will be installed at an appropriate height above the rooftop and the tallest nearby structures, except for the communication tower, to help increase vertical rise of exhaust emissions and improve plume dispersion. A halon-free fire-suppression system has been chosen to remove the possibility of a release of ozone-depleting substances.

4.1.1.3 Indirect Effects to Air Quality

Acidification of Coastal Areas

The indirect effects that may be caused by the Project include the possibility of damage to vegetation from the acidification of coastal areas. Olson (1982) has researched the levels of acidification from sulfurous pollutants that may cause damage to fruticose lichen that are common in the coastal tundra ecosystem of the North Slope (MMS 2008). This research suggests that SO_2 concentrations as low as 12.0 micrograms per cubic meter ($\mu g/m^3$) for short periods can depress photosynthesis in several lichen species, with damage occurring at 60 $\mu g/m^3$. The maximum modeled pollutant concentrations from the Liberty Project demonstrate that the concentrations are below the levels that can damage lichens, according to the laboratory studies conducted by Olson. Research at Prudhoe Bay from 1989–1994 showed no effects from pollutants on the vascular plants and lichens located there (MMS 2008). These data suggest that the Project will have no indirect effects to the vegetation in the region because the effects on air quality from the pollutant emissions associated with the Project will be equal to or less than the Liberty Project and the Prudhoe Bay complex.

Arctic Haze

Arctic haze is described as a reddish-brown layer in the atmosphere that occurs in high latitudes in the Arctic because of man-made pollution that causes reduced visibility. The results of research reveal that most of the pollutants that contribute to the formation of Arctic haze originate from industrial pollution from sources in Europe and Asia and not primarily because of local sources of air pollution. This evidence is supported by the fact that Arctic haze has been observed in the North Slope region as early as the 1950s, well before the major oil and gas development of the North Slope began. As production continues to decrease on the North Slope, the expected contribution to Arctic haze from oil and gas production facilities in the Prudhoe Bay/Kuparuk River Unit complex is expected to decrease. The air pollutant emissions from the Project will contribute only a small percentage to the overall emissions from the area. Therefore, the contribution to Arctic haze from the Project is expected to have no measurable effect on the area.

4.1.1.4 Conclusion

The direct effects to air quality that may result from the Project are expected to be minor in the immediate vicinity of the project area with no measurable effects at a distance of 6.2 miles (10 kilometers) or greater. Meteorological data show that any effects from the Project will likely occur downwind to the west, away from the sensitive areas on the Refuge and Kaktovik and will not extend out to any rural community to the west, including Nuiqsut. Current ambient air data show that air quality in the highly developed area of the Prudhoe Bay complex continues to meet the primary NAAQS and AAAQS (see Table 3-2). These data indicate that the Project, which will release a smaller amount of air pollutant emissions, will also meet the air quality standards. The indirect effects to air quality may include reduced visibility from activities associated with the Project, but will be mitigated through the use of water on gravel roadways and pads and speed limits designed to limit the formation of fugitive dust. Indirect effects such as acidification to coastal soils and Arctic haze are not expected by the activities associated with the Project. The environmental consequences to air quality from the Project will result in a minor effect to air quality that will not adversely affect public health or welfare (see Table 4-4).

TABLE 4-4: SUMMARY OF THE LIKELY EFFECTS ON AIR QUALITY

Project Phase	Assessment Criteria				Overall Effect
Project Activity/Component	Intensity	Scope/Magnitude	Duration	Context	
Drilling					
Combustion of fossil fuels in rig engines, heaters, and boilers	Low	Regional	Long-term	Common	minor
Combustion of fossil fuels in portable and mobile drilling equipment	Low	Regional	Long-term	Common	minor
Construction					
Combustion of fossil fuels in mobile and portable equipment used in construction of pads, roadways, airstrip, and pipelines	Low	Local	Temporary	Common	minor
Roadway traffic	Low	Local	Temporary	Common	minor
Gravel Mining and Placement	Low	Local	Temporary	Common	minor
Operations					
Combustion of fossil fuels in stationary equipment associated with the production of oil and gas	Low	Regional	Long-term	Common	minor

4.1.2 Geology and Geomorphology

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.1.2. Consequences are presented for drilling, construction, and operations. It analyzes the effects on the area's physiography and stratigraphy, seismicity, and faults, sand and gravel resources, paleontological resources, geomorphic processes, permafrost and ground temperatures, contaminated sites, and disturbed areas. It weighs the severity of the effect and the prospect of mitigation.

4.1.2.1 Physiography and Stratigraphy

The Project occupies the Arctic Coastal Plain (ACP), a physiographic province that encompasses thousands of square miles along the Beaufort Sea coast. It is characterized by a low-lying smooth plain covered by tundra, shallow lakes, and ponds. The terrain rises gently to the south and it is underlain by hundreds of feet of permanently frozen unconsolidated sediments. Project activities affecting physiography and stratigraphy will include (1) creating a new material site to mine sand and gravel; (2) using the material to construct and maintain pads, access roads, and the airstrip; and (3) constructing pipelines. Drilling and construction will produce direct and inevitable effects. They include the compression/destruction of surficial vegetation and organics because of gravel placement, addition of a localized new stratigraphic layer (the embankments), and pulverization and fracture of sediments and bedrock during drilling of wells and installation of piles. There are no expected direct effects on the physiography and stratigraphy during operations once facilities are constructed.

These direct effects, assuming some level of pad construction during the drilling phase, should be minor because the proposed excavations are shallow, the proposed embankments to be constructed and maintained are expected to be less than 10 feet thick, and the volume of rock and sediments in drill holes is limited to the borehole diameter. The disturbance to the landscape is not expected to extend more than a few yards beyond the footprint of the planned facilities. The landscape will maintain its character, except at the specific locations of the various gravel embankments, stockpiles, material site, and coastal facilities. Operations are not expected to produce direct effects on the physiography and stratigraphy once facilities are constructed.

Indirect effects may include slight degradation of permafrost and ponding, over time, near fill margins.

4.1.2.2 Seismicity and Faults

While strong ground shaking and potential soil liquefaction appear to be the primary earthquake processes or hazards that could potentially affect the Project, no mapped active surface faults appear to be across the Project elements. There are active and potentially active faults offshore in Camden Bay (Grantz et al. 1983; Pflaker et al. 1994), but the largest historical earthquakes associated with these faults have only been moderate magnitude (e.g., $\leq$ Magnitude [M] 5.3) (Combellick 1994), and also likely would not have had associated rupture of the sea bottom to generate a local tsunami.

Earthquake Shaking

Strong ground shaking from earthquakes can result in wave propagation damage to pipeline facilities, particularly for aboveground structures, if the shaking is strong enough. Earthquake strong ground shaking is commonly characterized by peak ground acceleration (PGA), and correlations of PGA to perceived shaking and potential damage to surface structures have been made by the University of Washington (2001). Such correlations are summarized in Table 4-5.

Regional-scale, probabilistic seismic hazard mapping for Alaska (Wesson et al. 2007) indicates that the 475-year return period (10 percent probability of exceedance in 50 years) PGA is generally less than about 0.10 g (acceleration from Earth’s gravity) for the project area. The 2,475-year return period (2 percent probability of exceedance in 50 years) PGA may range from about 0.13–0.22 g for the Project area (Wesson et al. 2007).

TABLE 4-5: PEAK GROUND ACCELERATION, PERCEIVED SHAKING AND POTENTIAL DAMAGE

Peak Ground Acceleration (PGA) (g)	Perceived Shaking (by Humans)	Potential Damage (to Surface Structures)
< 0.0017	Not Felt	None
0.0017-0.014	Weak	None
0.014-0.039	Light	None
0.039-0.092	Moderate	Very Light
0.092-0.18	Strong	Light
0.18-0.34	Very Strong	Moderate
0.34-0.65	Severe	Moderate to Heavy
0.65-1.24	Violent	Heavy
> 1.24	Extreme	Very Heavy

Notes:
Source: Taken and modified from University of Washington (2001).
g = acceleration from Earth's gravity
< = less than
> = greater than

Probabilistic seismic hazard deaggregation for the Project (using Latitude 70.1441 north [N]; Longitude 146.4093 west [W]), which is based on the available U.S. Geological Survey (USGS) 1996 probabilistic seismic hazard mapping data (USGS 2009), indicates that the expected PGAs for the 10 percent probability of exceedance in 50 years (475-year return period), and the 2 percent probability of exceedance in 50 years (2,475-year return period) are 0.06 g and 0.14 g, respectively. The 475-year return period PGA of 0.06 g is based on a mean moment magnitude (M_W) 5.83 earthquake located at a distance of 25 miles, the 2,475-year return period PGA of 0.14 g is based on a mean M_W 5.96 earthquake located at a distance of 12 miles (USGS 2009). Using the PGA, perceived shaking and potential damage correlations tabulated above, one can compare them to the expected future shaking in the Project vicinity for the 475-year and 2,475-year return periods. These are presented in Table 4-6.

TABLE 4-6: COMPARISON OF THE EXPECTED PEAK GROUND ACCELERATION IN THE POINT THOMSON PROJECT VICINITY TO PERCEIVED SHAKING AND POTENTIAL DAMAGE

Return Period (years) Point Thomson Project Vicinity	Expected PGA[1] (g)	Perceived Shaking (by humans)[2]	Potential Damage (to surface structures)[2]
475-year	0.06	Moderate	Very Light
2,475-year	0.14	Strong	Light

Notes:
[1] PGA from U.S. Geological Survey (2009) using 1996 seismic hazard mapping data.
[2] Correlation of PGA to perceived shaking and potential damage from University of Washington (2001).
g = acceleration from Earth's gravity
PGA = peak ground acceleration

Table 4-6 shows that the expected earthquake shaking, even using relatively conservative 2,475-year return period PGA values, results in only light potential damage. It is noteworthy that the Trans Alaska Pipeline System (TAPS) was subjected to a measured near-field PGA of at least 0.36 g from the 2002 M_W 7.9 Denali Earthquake (Ellsworth et al. 2004) and only experienced minor damage to aboveground pipeline support structures consistent with the original seismic design premise (Hall et al. 2003). It is also noteworthy that there was no damage to the TAPS pipeline itself, such as wrinkling, buckling, or excessive curvature (strain) conditions resulting from the earthquake shaking (Hall et al. 2003).

Mitigation Measures: The potential effects of earthquake shaking on the structures of the Project will be mitigated by seismic design consistent with the expected earthquake shaking level and consistent with appropriate seismic design criteria. The seismic design will nominally be for the operational period. Because of the short durations of the drilling and construction periods, seismic design and implementation are not planned.

The Project has no anticipated effects, either direct or indirect, on the seismicity or faults because the project has no actions during drilling, construction, or operations of a scale that would induce loads that are large enough to affect seismicity.

Soil Liquefaction

Saturated (e.g., high groundwater table), loose, granular soil (e.g., gravel, sand, silty sand, and sandy silt) can be susceptible to soil liquefaction during strong earthquake shaking. Liquefaction may result in excessive local ground settlement, lateral spreading with permanent ground deformation, and buoyancy of buried utilities. However, most of the soils in the Project area are continuously frozen all year and those that are seasonally thawed are limited to, at most, a thickness of only a few feet. These frozen conditions substantially limit the potential for liquefaction to occur. Effects on the Project from liquefaction would be expected to be minor.

4.1.2.3 Sand and Gravel Resources

The Project will require the development of a new 60-acre material site to meet the need for sand and gravel. The depth and work limits of this site may ultimately need to be modified. The main direct effect of sand and gravel mining would be resource extraction. Other direct environmental effects associated with the extraction would be minor modification of local topography; loss of surface vegetation; scarring of the landscape; creation of a deep-water lake; and a temporary increase of dust, soil erosion, and siltation near the material site. Thawing of near-surface permafrost will likely produce ponding within the excavation. The excavation will fill with water that will be used for water supply during the life of the Project. These effects are minor because all activity occurs within a localized footprint. The scale of the planned extractions is relatively small compared to the extractions of sand and gravel at other material sites located on the ACP west of Point Thomson.

4.1.2.4 Paleontological Resources

Paleontological resources that could potentially be affected by the proposed development are limited to plant and animal remains from the Gubik Formation. The Gubik Formation is a Quaternary deposit of unconsolidated, overlapping, marine and nonmarine sediments that are less than two million years old. No older formations outcrop within the study area, nor are they known to be close to the ground surface.

Direct effects to paleontological resources may include damage during excavations for sand and gravel, or burial by placement of fill. These potential effects are minor because there are no documented paleontological sites within the Project area. There will be a survey of cultural resources before commencement of ground disturbance that may locate any fossils on the surface, and most fossil remains are likely to be buried below the top of the permafrost. Being cased in permafrost, it is unlikely that fossils more than a couple of feet deep would be affected by either a spill or subsequent spill clean-up effort.

4.1.2.5 Geomorphic Processes

Drilling is not expected to have any effect on geomorphic processes because the duration and footprint of the drilling activities are limited. Construction and operation will result in direct effects from alteration of natural drainage, leading to ponding, and erosion where the new embankments can locally impede or accelerate the flow of water. The effects are likely to be minor because the climate is arid; no significant streams traverse the Project area; the terrain is relatively flat, limiting water velocity; and permafrost is continuous and close to the surface. The frozen ground resists erosion, particularly during the spring thaw when the seasonally frozen ground extends to the top of the permafrost. Shallow thaw lakes are sensitive to drainage and are generally transitory in nature. Blocking drainage can lead to localized ponding and thawing of near-surface permafrost, which may cause additional settlement. Settlements can alter the thaw lake pattern causing the formation of new lakes and ponds and the draining of existing lakes. These effects can be mitigated by proper drainage design and maintenance.

4.1.2.6 Permafrost and Ground Temperatures

The direct effects to permafrost and ground temperatures will be from the disturbance of the surficial organics by stripping for extraction of sand and gravel and by the construction of fills for pads, roads, the airstrip, and other facilities. Fills compress the surficial organic layer and thereby reduce its insulating value. Depending on the thickness of fill, this will allow permafrost to either aggrade up into the fill or to lower the permafrost table underlying the fill. At the embankment margins where the fill is thin, the underlying permafrost is likely to thaw and, where it is ice-rich, the soils may settle.

Excavations, such as the material site, will destroy local surface vegetation and may lead to thawing of the underlying permafrost, altered drainage, surface subsidence, and ponding. These direct effects are expected to be minor because they are likely to be localized to the footprint and immediate margins of the affected areas.

Drilling and operation of wells induces heat into the ground and, depending on the temperatures in the wells and the duration of their operation, thaw bulbs can develop around the well casings. These effects are moderate because the thawing can lead to collapse of ice-rich near-surface soils around the well, particularly where ice-wedges are within the range of the developing thaw bulb. These effects can be mitigated by well design, insulation around the well, passive refrigeration, and other methods.

Apart from any effects of the Project itself, global climate change may have an indirect effect on the ground temperatures and permafrost by increasing the average temperature of the soils, melting ground ice, releasing melt-water, and lowering the permafrost table. The extent of these indirect effects of the warming trend depends on many factors, such as the magnitude of the warming in the coming years, the thermal regime of the permafrost and the character and thermal conductivity of the geologic materials.

4.1.2.7 Contaminated Sites

According to the State of Alaska Contaminated Sites (CS) database, only two contaminated sites remain open with gravel impacted by diesel fuel: (1) the ExxonMobil Bullen Point Support Pad, also referred to as the Bullen Point Staging Area, and (2) the North Staines River No. 1 Gravel Pad.

4.1.2.8 Disturbed Areas

Some areas previously disturbed by man-made activities may be directly affected by the Project development. The proposed Central Pad will modify and expand an existing exploration pad. The proposed East Pad will occupy a portion of another exploration pad. These effects are expected to be minor and limited to regrading or covering of existing fill with new fill. Exxon Mobil Corporation (hereinafter ExxonMobil) is in the process of assessing areas previously disturbed by oil field activities. Some of these sites may be recommended for further restoration by spreading organic overburden from the new material site, or by some other appropriate action.

4.1.2.9 Conclusion

The Project’s drilling, construction, and operations have generally minor effects on the area’s geology and geomorphy (see Table 4-7). Moreover, most effects can be mitigated with proper design and maintenance. The Project has no effect on seismicity or faults. Its effect on physiography, stratigraphy, and geomorphic processes are largely due to alteration of natural drainage and soil disturbance. They are minor in that they are limited to a localized footprint. The moderate effects of heating the permafrost can be by alleviated with proper design. Sand and gravel extraction is inevitable. Paleontological resources, contaminated sites, and disturbed areas are largely unaffected.

TABLE 4-7: SUMMARY OF LIKELY EFFECTS ON GEOLOGY AND GEOMORPHOLOGY

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Drilling				
Disturbance to Physiography and Stratigraphy	Fill placement during drill pad construction Fracturing of sediments and rock during drilling Adding stratigraphic layer (embankments)	Local Local Local	Long Term Long Term Long-Term	Moderate Minor Minor
Disturbance to Seismicity and Faults	Liquefaction during an earthquake	Local	Temporary	Unlikely or Very Minor
Removal of Sand and Gravel Resources	Resource extraction for drill pad construction	Local	Temporary	Minor
Damage to Paleontological Resources	Excavations for sand and gravel Burial by fill Coating with petroleum during spill	Local Local Local	Temporary Long-Term Temporary	Minor Minor Minor
Disturbance to Permafrost and Ground Temperatures	Fill Placement Drilling	Local Local	Long-Term Temporary	Minor Minor
Alterations to Disturbed Areas	Re-grading	Local	Long-Term	Minor
Construction				
Disturbance to Physiography and Stratigraphy	Fill placement during construction Fracturing of sediments and during VSM installation Adding stratigraphic layer (embankments)	Local Local Local	Long-Term Long-Term Long-Term	Moderate Minor Minor
Disturbance to Seismicity and Faults	Liquefaction during an earthquake	Local	Temporary	Unlikely or Very Minor
Removal of Sand and Gravel Resources	Resource extraction for road, airstrip and pad construction	Local	Temporary	Minor
Damage to Paleontological Resources	Excavations for sand and gravel Burial by fill Coating with petroleum during spill	Local Local Local	Temporary Long-Term Temporary	Minor Minor Minor
Disturbance to Geomorphic Processes	Fill placement leading to drainage alteration, ponding, erosion, and alteration of lake patterns	Local	Long-Term	Minor
Disturbance to Permafrost and Ground Temperatures	Fill Placement Drilling	Local Local	Long-Term Long-Term	Minor Minor
Alterations to Disturbed Areas	Regrading	Local	Long-Term	Minor
Operations				
Disturbance to Physiography and Stratigraphy	Fill placement during maintenance of embankments	Local	Temporary	Minor

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Disturbance to Seismicity and Faults	Liquefaction during an earthquake	Local	Temporary	Unlikely or Very Minor
Removal of Sand and Gravel Resources	Resource extraction for maintenance of roads, airstrip and pads	Local	Temporary	Minor
Damage to Paleontological Resources	Burial by fill Coating with petroleum during spill	Local Local	Long-Term Long-Term	Minor Minor
Disturbance to Geomorphic Processes	Fill placement leading to drainage alteration, ponding, erosion, and alteration of lake patterns	Local	Long-Term	Minor
Disturbance to Permafrost and Ground Temperatures	Fill Placement	Local Local	Long-Term Long-Term	Minor Minor
Alterations to Disturbed Areas	Regrading	Local	Long-Term	Minor

4.1.3 Fresh Water Resources and Hydrology

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.1.3. Consequences are presented for drilling, construction, and operations.

4.1.3.1 Drilling

Gravel Pads

Three gravel pads are proposed for this Project: Central Pad, West Pad, and East Pad. Central Pad will be an expansion of an existing gravel pad. East Pad incorporates part of an existing gravel pad, with the main pad offset for protection from coastal erosion. West Pad will be a new pad.

The gravel pads have the potential to affect existing drainage patterns and water quality, and to increase thermokarst conditions. If located improperly, the gravel pads have the potential to block or restrict drainage during normal or flooding conditions. As a result of constructing the gravel pad, thaw settlement may occur at the toe of the pad. If water pools in the thaw settled area, the amount of thaw settlement may increase. If runoff leaves the gravel pads, the runoff has the potential to affect surface water bodies and tundra near the pad.

Thus, the gravel pads will be constructed such that they do not block drainage or present a significant restriction during either normal riverine flow or flood events. To the extent practical, gravel pads will be designed such that water does not pool at the toe of the pad. If water does pool along the toe of a pad, an assessment of the situation will be made and best management practices (BMPs) will be used to minimize the effects on the environment. If any of the gravel pads are located within the floodplain of a river or stream, they will be designed to withstand the erosional forces during an appropriate design event. Gravel pads will be designed such that the anticipated water surface elevation of the 100-year riverine flood or storm surge, plus a suitable freeboard, is at or below the top of the pad. Stormwater runoff from the gravel pads is addressed in Section 4.1.3.1 Drilling; Permitted Discharges. Stormwater Pollution Prevention Plans will be developed and implemented to reduce the potential for contaminated runoff from gravel pads. By using these practices, it is expected that the gravel pads will have a minor effect on drainage, water quality, and thermokarst conditions.

Ice Roads

Ice roads will be constructed on the tundra and inland water bodies, and offshore. The potential effects of ice roads on the tundra and inland bodies of water will be discussed first. Onshore ice roads have the potential to affect existing drainage patterns and to increase erosion and sedimentation. Onshore ice roads tend to take longer to melt than the normal snowpack and thus can cause obstructions or blockages within normal drainage paths. Obstructions to local flow patterns can increase erosion within the drainage channel. Both obstructions and blockages can result in water pooling where such pools do not normally form and/or increased water surface elevations during break-up.

To reduce the potential for onshore ice roads to affect drainage patterns and cause erosion/sedimentation, the ice roads may be breached at known drainage paths before snowmelt runoff begins. Additionally, it is anticipated that breaching will be required by Title 16 permits for anadromous fish streams. As a result, ice roads should have a minor effect on drainage, erosion/sedimentation, and water quality. The long term effects of the ice roads should also be minor, because ice roads are not normally constructed in the same location from one year to the next.

Offshore ice roads will be built on existing sea ice and it is anticipated that they will have a minor affect on the marine environment. In some cases the offshore ice road could cause water to back up at the mouth of a river during spring break-up, and inundate areas that would not have been inundated if the ice road had not been built. However, because of the flatness of the terrain, it is anticipated that if water does back up as a result of a sea ice road, the increase in the depth of the water will be small and the effect on the environment will be minor.

Water Withdrawal

Fresh water is required for drilling, camp operations, and the construction of ice roads. Sea water and chipped ice will also be used for the construction of sea ice roads. Before construction of the gravel mine site/water supply reservoir, the water required for drilling, camp operations, and the construction of ice roads will primarily come from lakes and other old mine sites, but may also come from one or more nearby waterbodies and/or Deadhorse. The locations from which water removal has been previously permitted are presented in Table 3-11 and shown on Figure 3-9. During the winter, water will be removed from lakes through a hole in the ice and trucked to where it is needed. During the open water season, water may be removed from lakes, existing water supply reservoirs, or Deadhorse and transported to the Central Pad. Another option is to use submersible pumps to remove water from nearby lakes or streams and transport it through temporary pipelines to the Central Pad. Once the new water supply reservoir is constructed and filled, it will be the primary source of fresh water for the Project. It is anticipated that the water supply reservoir will be filled for the first time during the 2012 spring break-up.

The potential effects on the fresh water resources and the hydrology of the Project area from lake and stream water withdrawal include reduced water levels and a reduction in the available dissolved oxygen (DO). Water withdrawal is controlled by state permits, which limit the amount of water that can be withdrawn and include requirements for fish protection. Lakes not previously surveyed will be surveyed before withdrawing water to determine the amount of water available for withdrawal. The effects of water withdrawal on the fresh water resources and the hydrology of the Project area are expected to be minor.

Permitted Discharges

Surface discharges have the potential to affect water quality associated with nearby surface water bodies and groundwater; and, to increase thermokarst conditions. All discharges to surface water will be permitted to comply with regulations designed to prevent or minimize adverse effects.

To reduce the potential for permitted discharges to affect surface water quality, an EPA Class I (Industrial) disposal (underground injection control [UIC]) well will be constructed at the Central Pad. Water produced from drilling, domestic wastewater from construction and permanent camps, liquid wastes, and drilling wastes will be injected into the well. EPA has generally determined the sub-permafrost groundwater is not an underground source of drinking water. Therefore, the effect of permitted discharges on groundwater is considered to be minor.

At times, when the disposal well is not available, and before it is operational, treated domestic wastewater and hydrotest waters may be discharged to surface water under the requirements of a General National Pollutant Discharge Elimination System (NPDES) Permit or Alaska Pollutant Discharge Elimination System Permit (APDES). Discharges to fresh water are anticipated to be short-term and to only occur during start-up and limited periods when the UIC well is down for maintenance or emergency situations. Planned discharges will meet the NPDES/APDES effluent requirements for surface water disposal. BMPs will be used to minimize effects to tundra and surface water. Surface disposal will be very limited and intermittent; therefore, effects to the surface water quality and thermokarst conditions are expected to be minor.

Stormwater runoff will be controlled, and as needed, permitted under the NPDES/APDES General Permit as surface water drainage. Stormwater runoff could contain sediment from the gravel pads and roads and/or contaminants from construction or operations materials spilled on the gravel pad and roads. BMPs will be developed and used to mitigate stormwater contamination resulting in only minor effects to surface water quality and thermokarsting.

Spills

Section 4.4 (Product Spill Risk Analysis) contains a detailed discussion of the probability of spills and potential effects. If spills of petroleum products, other chemicals or wastes generated from drilling activities reach a nearby body of water, they have the potential to affect the water quality of that water body. The extent and duration of the effect depends upon the chemical makeup of the product spilled, the duration of the spill, the volume of the product spilled, the volume of the body of water, the chemical makeup of the water body, the season, and the responsiveness and experience of the clean-up crews (see Section 4.4).

All procedures, training, engineering designs, and spill response organizational structures described in the state-approved Oil Discharge Prevention and Contingency Plan (ODPCP) and in the respective federal Response Action Plans will be employed to prevent spills and to respond effectively should a spill occur. A Spill Prevention Control and Countermeasures (SPCC) Plan will be in place at all facilities. Both the ODPCP and SPCC plans will be updated every five years and whenever changes in facility design that significantly affect spill potential occur.

The Project reservoir is largely gas and condensate, but the possibility of a crude oil spill also exists. In the unlikely event that a large spill occurs, water resources could be adversely affected, especially if crude oil were to be released. Effects from a large gas and condensate spill or blowout on water resources would most likely be minor to moderate. This is because condensate is a low-density mixture of hydrocarbons consisting largely of C_2–C_{12} alkanes and low-molecular-weight aromatics and does not exhibit the environmental persistence that heavier oils do. The effects on water resources in the event of a blowout or large spill of crude oil could be major. Crude oil is more complex chemically and more persistent in the environment and could present more serious effects to surface water and tundra.

The vast majority of spills on the North Slope over the past 30 years have been small (see Section 4.4). Drilling will occur from gravel pads, which lessens the likelihood of spilled materials reaching surface water or tundra. A loss of well control during drilling would pose more of a threat to surface water and tundra. The use of blowout preventers and other advances in well control technology make such an event unlikely.

Storage of fuels, and refilling of equipment and machinery, will be conducted following the fuel transfer guidelines and liner procedures outlined in Section 7 of the North Slope Environmental Field Handbook (BPXA and ConocoPhillips Inc. 2005) and the refueling guidelines provided in Section 17 of the ExxonMobil Production Company Safety Manual. Employees will be trained in the proper methods and authorized locations for refueling. Fuels will be properly stored in approved containers and stored in areas with proper containment.

On the basis of well design and control technologies and prevention and response practices, the potential for a large spill to occur is expected to be low (see Section 4.4); but if one occurs, the effect on water resources could be moderate to major. Because North Slope water resources are covered with ice and snow during a majority of the year there would be additional time to respond and clean up spills, thereby reducing the probability of a moderate to major effect. Effects of smaller spills on water resources are expected to be none to minor.

4.1.3.2 Construction

Pipelines

Construction of pipelines has the potential to increase erosion and thermokarst conditions along the pipeline right-of-way. Except for road crossings, pipelines will be constructed above ground. If vertical support members (VSMs) are located within a channel or floodplain, the turbulence created by water flowing around a VSM may cause localized erosion (i.e., scour) immediately adjacent to the VSM and loss of load-bearing capacity. Ice floes may also accumulate against the VSM and the resultant water surface elevation increase may increase the lateral load on the VSM. Each of these mechanisms, on their own or in concert, could compromise the integrity of the pipeline and cause a release of product. Additionally, localized erosion at the VSM can result in an increase in the amount of sediment being transported downstream.

Several engineering practices will be used to address these concerns. The Project pipelines will be elevated throughout their entire length, with a minimum of 7 feet between the tundra surface and the bottom of the pipeline. The use of elevated pipelines allows visual inspection of the pipelines for leaks and largely removes them as a potential heat source within the tundra. Leak monitoring of the gathering lines and the export pipeline will include pressure monitoring and control safety systems. The pipelines will be built in the winter from ice roads. Thus, the effects of pipeline construction on tundra, lakes, and streams will be reduced from what could occur if construction were from gravel roads at other unfrozen times of the year. Where pipelines cross rivers and streams, the bottoms of the pipelines will be designed to be above the 200-year flood water surface elevation plus an appropriate freeboard.

Although locating VSMs within a river channel or a lake will be avoided to the extent practicable, horizontal span-length restrictions on the pipeline may require such location. Those VSMs located in river channels and floodplains will be designed to accommodate the maximum scour depth that is likely to occur during a 100-year flood. Although past observations have indicated that significant ice floes will probably not occur on many of the rivers and streams crossed by the proposed pipelines, if ice floes are anticipated on a particular river, the VSM in that crossing will be designed to withstand the resultant potential forces.

By using these practices, the effects of the pipelines on the water quality of nearby bodies of water are expected to be minor, and negative effects on thermokarst conditions should not occur. Because the scour holes formed around the VSMs usually develop during a relatively short timeframe and a relatively large event, it is expected that the effect of the VSM on the long-term sediment transport characteristics of the river or stream will be none to minor.

Gravel Roads and Airstrip

Gravel roads and the airstrip have the potential to affect existing drainage patterns and to increase erosion and sedimentation. As a result of constructing a gravel road, thaw settlement may occur at the toe of the road. If water pools in the thaw-settled areas, the amount of thaw settlement may increase. To a large extent, the magnitude of the effect of roads and airstrips on streams and rivers is dependent upon the type and size of the drainage structures and the techniques used to construct and maintain the roads and airstrip.

Road and airstrip crossings of streams and rivers on the Project will consist of single culverts, multiple culverts or bridges. Significant effects from stream-crossing structures are most likely if drainage structures are missing, undersized, or improperly constructed. The lack of a drainage structure can result in excessive pooling of water on the upstream side of the road, drying of the tundra on the downstream side of the road, and/or more-frequent-than-expected overtopping of the road. Excessive pooling of water on the upstream side of the road can lead to thaw settlement along the upstream toe of the road; undermining the integrity of the road. It can also damage the local vegetation. Overtopping of the road can lead to erosion of the road and possibly a washout. The sediment eroded from the road adds to the sediment load of the flow and may be deposited on the tundra or within the stream channel at a location downstream from the road. Excessive sedimentation on the tundra can negatively affect the tundra vegetation: and excessive sedimentation in a stream channel can destabilize the stream banks, causing the stream to widen and/or creating a fish block. Undersizing of a drainage structure can result in frequent overtopping and erosion (possibly washout) of the road or airstrip, excessive pooling of water on the upstream side of the structure, excessive velocities and erosion within (bridge) and/or at the outlet (culvert) of the structure, and/or fish passage issues at the structure.

Poor construction techniques, such as the use of frozen backfill at culverts or inadequate compaction, can result in large-diameter culverts collapsing and thaw settlement of the road that can lead to more-frequent-than-anticipated overtopping of the road. If the toe of the road is too close to the inlet and outlet ends of a culvert, gravel from the road can eventually block or partially block the ends of the culvert. If a road/stream crossing must be repaired during the open water season, the potential for sediment to enter the stream exists as a result of the construction activities.

The proposed roads will be located south of the proposed pipelines, along an alignment that is somewhat drier than the pipeline alignment. This will reduce the effect of the roads and airstrip on the tundra in the Project area. Several practices will be used to mitigate the effect resulting from drainage structures and drainage structure construction techniques. Bridges will be designed such that the low chord of the bridge is above the 50-year water surface elevation plus a freeboard based on the potential for ice floes, waves, and the uncertainties involved in computing the design water surface elevation. The piers and abutments will be designed to accommodate the scour likely to occur in a 50-year or less-frequent (i.e., higher return period) flood. Culverts will be located where drainage is required and a bridge is not necessary. Culverts will also be placed in areas where spring break-up water is likely to overtop roads. The number of culverts and sizes required at each location will be determined, and culverts will be sized to accommodate peak flows and avoid excessive blockage by sediment from roads and drifting snow. Culverts will be designed to prevent damage from heavy loads and to prevent erosion at the outlets. Culverts that require fish passage will be designed based on criteria used by the Alaska Department of Transportation (ADOT), Northern Region, and described in the Memorandum of Understanding between ADOT and Alaska Department of Fish and Game (ADF&G) (State of Alaska 2001) on the design and construction for fish passage. By using these practices, effects of the gravel roads and airstrip on water quality, erosion and sedimentation, and drainage pattern are expected to be minor.

Gravel Pads

The potential effects associated with gravel pads during construction and the measures proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling.

Ice Roads

The potential effects associated with ice roads during construction and the measures proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling.

Material Site

The primary source of gravel for the Project will be a new gravel mine site located approximately 2 miles south of the Central Pad. Approximately 2.65 million cubic yards (cy) of gravel and 730,000 cy of overburden will be removed from the approximately 60-acre mine site. Gravel will be removed from the mine only during the winter months when the soils and tundra are frozen. Once mining activities are complete, the mine site will be used as a fresh water reservoir. To fill the mine site with water, a diversion channel will be constructed to divert water from the adjacent stream during spring break-up.

Potential effects related to construction and operation of the gravel mine site on fresh water resources and hydrology include: erosion of the sides of the mine site resulting from surface water entering the mine site, and sediment eroded from the stockpiles being deposited on the tundra. Erosion of the side slopes is a problem if it results in a channel being eroded upstream from the mine.

When the mine site is converted to a water supply reservoir, an approximately 50-foot-wide diversion channel will be constructed between the river adjacent to the east side of the mine site and the mine site. To prevent the diversion channel from eroding, the diversion channel will be armored at least 20 feet beyond the toe of the mine site slope to the stream end of the diversion channel. The technique used to provide the erosion protection will take into consideration, the fact that the water supply reservoir may be empty or nearly empty at the beginning of spring break-up, when the reservoir will be filled. The bottom of the diversion channel will be approximately 1 foot above the stream bottom. To control when water enters the material site and to maintain water in the stream during periods of normal and low flow, a weir will be constructed within the diversion channel.

The effect of the proposed mine site/water supply reservoir on the fresh water resources and hydrology of the Project area is expected to be minor as a result of the operational and design practices used at the mine site. Additionally, the stormwater runoff from the stockpile will be permitted (see Section 4.1.3.1, Drilling; Permitted Discharges).

Water Withdrawal

The potential effects associated with water withdrawal and the practices proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Permitted Discharges.

Permitted Discharges

The potential effects associated with permitted discharge and the practices proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Permitted Discharges.

Spills

The potential effects to water quality associated with spills and the practices proposed to reduce the potential effects are the same as those described in Section 4.4, Product Spill Risk Analysis.

4.1.3.3 Operations

Pipelines

During operations, the largest potential for the pipelines to affect the fresh water resources of the Project area is by a pipeline spill, or spills from vehicles used during routine maintenance and visual inspections. To reduce the potential for a spill, the pipeline will be constructed to strict guidelines and the gathering lines will be constructed of Corrosion Resistant Alloy (CRA). Additionally, the pipeline will be monitored and routine maintenance performed. Routine monitoring will consist of continuous leak detection monitoring, periodic visual inspections, integrity surveillance with in-line inspection tools, corrosion monitoring, and pressure monitoring.

With these systems in place, the effects of the proposed pipelines on the fresh water resources of the Project area are expected to be minor.

Gravel Roads and Airstrip

During operations, the largest potential for the gravel roads and airstrip to affect the fresh water resources of the Project area is by damaging the drainage structures, by snow blocking the drainage structures, or by poor maintenance procedures. Heavy loads, in excess of the loads anticipated during design, can cause culverts to be broken and eventually collapse. Snow blockage in the spring can cause a drainage structure to pool an excessive amount of water, leading to road overtopping and possible washout. Poor maintenance practices include grading the top of the road such that over time the road becomes thinner and wider. This can result in thermal degradation of the permafrost under the road and to gravel blocking the ends of the culvert.

To reduce the risk of these effects, if it becomes necessary to move loads that are in excess of the loads assumed during the design of the culverts along a road, rig mats will be placed over the culverts and/or temporary bracing will be added to the inside of the culverts. If snow blockage in the spring is preventing some culverts or bridges from performing adequately, it may be necessary to begin a spring maintenance program to remove the snow from the drainage structures. Roads will be graded such that the material pushed over the edge of the road is brought back to the top of the road, to the extent practicable. The effect of the proposed roads and airstrip on the fresh water resources of the Project area is expected to be minor.

Gravel Pads

The potential effects associated with gravel pads during construction and the measures proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Gravel Pads.

Ice Roads

The potential effects associated with ice roads during construction and the measures proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Ice Roads.

Material Site

During operations, runoff from the stockpiled gravel represents the greatest potential effect to the fresh water resources of the Project area. Runoff from the stockpile will be permitted (see Section 4.1.3.1, Drilling; Permitted Discharges) and because BMPs will be used to control the runoff from the stockpiled gravel, the effect of the runoff on the environment is expected to be minor.

Water Withdrawal

During operations, water withdrawal is anticipated to be primarily, if not solely, from the gravel mine site/water supply reservoir created for the Project. Thus, the effect to the fresh water resources and hydrology of the Project area is expected to be minor.

Permitted Discharges

The potential effects associated with permitted discharge and the practices proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Permitted Discharges.

Spills

The potential affects to water quality associated with spills and the practices proposed to reduce the potential effects are the same as those described in Section 4.1.3.1, Drilling; Spills.

4.1.3.4 Conclusion

Elements of the Project that could affect fresh water resources and hydrology include gravel structures (road, pads, airstrip), pipelines, material site development, ice roads, water withdrawal, permitted discharges, and spills. Based on engineering, administrative and regulatory controls, including proposed mitigation, effects to fresh water resources and hydrology (e.g., drainage patterns, water quality, erosion, sedimentation, and thermokarsting) are expected to be minor (see Table 4-8). In the event of a large spill, effects would be determined by the type of material spilled, size, location, duration and season of release, the receiving environment, and the effectiveness of response.

TABLE 4-8: POTENTIAL EFFECTS ON FRESH WATER RESOURCES AND HYDROLOGY

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Drilling				
Drainage pattern changes	Gravel pads. ice roads	Local	Temporary to Long Term	Minor
Water Quality Degradation	Gravel pads, ice roads, lake water withdrawal, permitted discharges, spills	Local	Temporary	Minor
Erosion	Ice roads, permitted discharges	Local	Temporary	Minor
Sedimentation	Ice roads, permitted discharges	Local	Temporary	Minor
Thermokarsting/thaw settlement	Gravel pads, permitted discharges	Local	Temporary to Long Term	Minor
Construction				
Drainage pattern changes	Gravel pads, roads and airstrip; Ice roads	Local	Temporary to Long Term	Minor
Water Quality Degradation	Gravel pads, roads and airstrip; pipelines, ice roads, lake water withdrawal, permitted discharges, spills	Local	Temporary	Minor
Erosion	Material site; gravel roads and airstrip; pipelines, Ice roads, permitted discharges	Local	Temporary	None to Minor
Sedimentation	Material site; gravel roads and airstrip; pipelines; Ice roads, permitted discharges	Local	Temporary	Minor
Thermokarsting/thaw settlement	Gravel pads, roads and airstrip, pipelines; permitted discharges	Local	Temporary to Long Term	None to Minor

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Operations				
Drainage pattern changes	Gravel pads, roads and airstrip; Ice roads	Local	Temporary to Long Term	Minor
Water Quality Degradation	Gravel pads, roads and airstrip; pipelines, ice roads, lake water withdrawal, permitted discharges, spills	Local	Temporary	Minor
Erosion	Material site; gravel roads and airstrip; pipelines, Ice roads, permitted discharges	Local	Temporary	None to Minor
Sedimentation	Material site; gravel roads and airstrip; pipelines; Ice roads, permitted discharges	Local	Temporary	Minor
Thermokarsting/thaw settlement	Gravel pads, roads and airstrip, pipelines; permitted discharges	Local	Temporary to Long Term	None to Minor

4.1.4 Physical Oceanography and Coastal Water Resources

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.1.4. Consequences are presented for drilling, construction, and operations. Elements of the Project are located along the shoreline of Lion Bay within the Beaufort Sea. The primary areas of concern associated with the Project's effects on coastal processes (e.g., storm waves, tide surges, ice movement and pileup, and river input) are associated with coastal erosion and littoral currents/longshore sediment transport.

4.1.4.1 Drilling

Most of the activities that could affect the shoreline during drilling would occur at the three pad sites. Activities near the shore-facing sides of these pads could divert normal surface flows, resulting in increased erosion of the ice-wedge polygons. This melting might result in the loss of soil strength and subsequent increased coastal erosion. To minimize erosion, armor protection will be placed along the seaward facing slopes of the Central Pad. Placement of armor will be conducted during construction, and is described in more detail in the following section.

4.1.4.2 Construction

During construction, most of the nearshore coastal activity would occur at the Central Pad. Of the three gravel pads included in the Project, the Central Pad is situated closest to the shoreline and two sheetpile bulkheads, or wharfs, will be constructed on the north side of the pad and used for offloading barges delivering large pre-fabricated facility modules and other drilling and construction equipment. On the east side of the Central Pad, the Emergency Response Boat Launch and adjacent access float and gangway are to be constructed and used throughout the duration of the Project for emergency response and oil spill mitigation and/or training.

The pad itself, due to its proximity to the shoreline, will include armor protection to minimize coastal erosion. Armor protection will be placed along the seaward facing slopes of the pad. A typical gravel bag armor protection design is presented in Figure 4-1.

The larger of the two sheetpile bulkheads is referred to as the High Bulkhead; that would be the more extensive facility, and used in conjunction with barges that will be grounded offshore to serve as a pier, or bridge, for offloading equipment. The barges would only be in place temporarily for about two weeks per year during each of the three years of construction. The second structure is referred to as Low Bulkhead and would be utilized throughout the duration of the Project.

The two bulkheads would be adjacent to each other on the north side of the Central Pad with the Low Bulkhead on the west side. The bulkheads would be constructed of open cellular sheet pile, which would help to contain the soils behind it and eliminate any direct beach erosion behind the structure. Fill for these structures would be gravel. The elevations (Mean Lower Low Water [MLLW] = 0 feet) for the two bulkheads are +20 and +5 feet, respectively, for the High and Low bulkheads. The toe of each bulkhead would be above Mean High Water (MHW), thereby minimizing water quality issues that would otherwise be a concern during pile driving. Placement of the bulkheads above MHW will require dredging or other means of deepening the water in front of the bulkhead in order to facilitate barge access. A ramp is planned to access the barges from the bulkhead and minimize the amount of deepening needed.

In addition to the bulkheads on the north side of the pad, a boat launch and adjacent access float and gangway are to be constructed for access by emergency response and oil spill mitigation and/or training vessels and personnel. The bulkheads and Emergency Response Boat Launch are described in detail in the following subsections.

High Bulkhead

The primary purpose of the High Bulkhead would be to provide a means of offloading heavy modules needed for field development and production. The barge bridge would consist of three seagoing barges approximately 400-feet long by 105-feet wide. Each barge would be loaded with modules upon its arrival at the site. The barges would be moored end to end with the shoreward-most barge or barges serving as a bridge to access the adjacent seaward barge or barges while offloading the modules. Because the barges would be located in increasing water depth in the offshore direction, each could be loaded differently with the heaviest loaded barge being in the deepest water. On the shoreward end, a gravel ramp would be constructed from the bulkhead elevation at +20 feet (MHW) about 300-feet laterally, down to the Central Pad surface at a 3 percent slope.

These barges would be in place for about two weeks during each of the three construction years. Each year when the ice opens the offshore barge ensemble would need to be reassembled into a three-barge bridge configuration so that its barges' contents could be offloaded. At the conclusion of this offloading operation, the barges would be removed from the bulkhead and removed from the Project area. The sheetpile bulkhead would remain in place.

Five mooring/breasting dolphins, each consisting of three driven steel pipe pilings, would be installed along the barge alignment to maintain a straight orientation for the barges. The dolphins would be driven before the barges arrive for the first time and would remain in place for at least the duration of the construction phase. The pilings would be driven into the seabed during the winter through a dry hole and therefore turbidity and suspended sediments will be minimized.

Each barge would be grounded in place by ballasting. Ballast water would consist of local marine water taken in at the site of grounding. Prior to the barges departing each season, it may be necessary to discharge a portion of the ballast water. If necessary, this water would be disposed at the Class I disposal well at the Central Pad.

A combination of screeding (grooming) or dredging of seafloor sediments would be used to achieve the required depths and to smooth the bottom to create a relatively level and even surface on which the barges will rest. To groom the majority of the nearshore, the grain size of the bottom material would probably need to consist of fine sand or larger. Geotechnical sampling and testing is expected to be completed in 2010 to confirm sediment removal and disposition procedures. Screeding and dredging of the seafloor would be conducted over an area of about 60,000 square feet, removing up to 1,500 cy of material. Geotechnical sampling is planned in 2010 and the results will help to confirm appropriate screeding/dredging procedures. Similarly, site-specific grain size analysis will help to determine appropriate sediment disposal/placement methods. It is anticipated that the material will be used for beach nourishment.

Fine-grained material would likely indicate that grooming or maintenance dredging would have to be conducted each year before the arrival of the barges. Fine-grained material could also result in an increase in the amount of suspended sediments and turbidity generated from this procedure. An updated sediment removal and disposal plan will be completed following the geotechnical sampling in 2010.

While the barges are in place, the littoral transport would be interrupted, causing sediment deposition on the upwind side and erosion on the downwind side of the barge array. Since the barges would only be in place for about two weeks during each of the three construction years, it is unlikely that any increased erosion would be significant. The bulkheads, located above MHW, are not expected to create a significant blockage because of the limited offshore projection and hence it probably would not create substantive effects.

It is possible that the material removed from nearshore during grooming or dredging might increase the wave heights that could reach shore and could enhance the development of ice ride-up and pile-up. The increased wave heights could enhance shore erosion locally and might require additional shore erosion protection. If the material removed by grooming is sufficiently large-grained, using it to nourish the beach directly where higher waves might be expected to impact the shore could be useful. With regard to increased ice movement, it is probable that this potential increase would be small and would probably be adequately countered by the vertical bulkhead on the shoreline.

Erosion at the toe of the vertical bulkheads could also occur over time. This could be mitigated by performing regular inspection and maintenance as needed.

Low Bulkhead

To better accommodate landing and offloading of the smaller coastal barges that are regularly used to support drilling and construction activities during the open water season, the Low

Bulkhead would be used. The Low Bulkhead would be constructed similar to the adjacent High Bulkhead, except it would be designed to accommodate smaller vessels. The top of the bulkhead would rise to only about +5 feet (MHW). A gravel ramp would extend upwards to the surface of Central Pad at a 3 percent slope.

Erosion at the toe of the vertical bulkheads could also occur, and to ensure structural stability, maintenance of the toe of the sheets may be needed.

Because the gravel ramp slopes down from the Central Pad to the Low Bulkhead, there is the potential for storm/meltwater runoff to flow down the ramp from the Central Pad and enter the ocean surface waters.

Emergency Response Boat Launch

A third equipment handling facility is planned at the Central Pad. The Emergency Response Boat Launch and adjacent Access Float and Gangway are to be located on the east side of the pad and used nearly exclusively by Alaska Clean Seas for emergency response and oil spill mitigation and/or training. The Emergency Boat Launch would be in use during the construction and operations phases. It would consist of a gravel ramp extending about 150-feet into the inlet down to approximately 3.5 feet below MLLW level. The gravel would be sloped at 13 percent and capped with concrete planks oriented parallel to the shoreline. The flanks of the ramp would be on a 2:1 slope and would be armored against erosion using concrete revetment or other appropriate slope protection and erosion control material. A gangway ramp and floating dock structure will be installed alongside the ramp. On the shore end, an 8-foot- by 50-foot-long timber approach trestle (or pier) will connect the Central Pad to the top of an 8-foot- by 85-foot-long gangway ramp that will be supported by two vertical steel piles and a connecting pile cap at both the upper and lower ends. Two pairs of piles will also be installed to support an 8-foot by 30-foot floating dock (i.e., Flexi Float). Pile hoops will attach the floating dock to the piles to allow it to move up and down with the tide. The seaward end of the floating dock will be similarly anchored using piles. Each of the steel piles will be driven into the ground to sufficient depths, as determined by a geotechnical study, to support the structures, intended loads, and to withstand wave and ice forces. This is intended as a permanent structure for the duration of the Project and would be maintained as necessary to ensure its functionality. During the winter season, the floats will require diligent maintenance to prevent them from being damaged by ice.

Because of its ramp leading out into deeper water and its elevation above MHW, the Emergency Response Ramp is likely to contribute to some sediment accumulation on one side and erosion on the opposite side. Given its more protected location, both of these effects would be expected to be minor.

The boat launch ramp might also provide easier access for ice riding or piling up above the shoreline, with the potential effects of increased erosion in the upland area and undermining of the concrete planks. But, ice effects are also believed to be insignificant, especially with regular maintenance.

Because the gravel ramp slopes down from the Central Pad, there is the potential for potentially contaminated storm/meltwater runoff to flow down the ramp from the Central Pad and enter the ocean surface waters. Additional effects may be associated with accidental discharges of hydrocarbon products to marine surface waters associated with any type of vessel operations.

4.1.4.3 Operations

As indicated in the previous section, the High Bulkhead barges would be removed following the module offloading operation(s) during construction. The bulkheads, the Emergency Boat Launch, and associated gangway and floating docks would remain in place. The obstruction to littoral transport caused by the bulkheads and the launch ramp would be likely to continue to cause a minor amount of increased erosion through the duration of the Project, but this should be extremely limited. The overall effect of these structures being in place is to cause a net reduction in erosion over that which would have occurred had the structures not existed.

Over time, because the bulkheads contain the soils behind it and the adjacent unprotected shorelines will continue to naturally erode, the bulkheads will eventually appear to protrude from the shoreline. At that point, the bulkheads could begin to interrupt the natural littoral transport of sediments and increased erosion and sediment accretion rates may be evident on either side of the structure. However, this can be mitigated by regular inspection and maintenance by placement of armor protection.

The vessel operations in the nearshore would cause a temporary increase in turbidity, but this would probably be comparatively less than that naturally created by wind, waves, currents, and erosion in the area on a routine basis. The possible increase in ice ride-up and pile-up that might occur because of the Project is not considered to be significant.

4.1.4.4 Conclusion

The potential environmental consequences of the Project on the characteristics of the existing physical coastal environment primarily include potential issues associated with erosion, suspended sediments, and littoral sediment transport (see Table 4-9). These potential direct and indirect effects are expected to occur primarily during the construction phase. Structures planned to be located along the shoreline of Lion Bay include the Central Pad and its two bulkheads, vessel launch ramp and related structures.

In general, structures located along a coastline could be expected to cause some direct and indirect effects on the coastal environment associated with erosion due to the structure blocking the littoral transport of sediments along the shoreline, as well as dredging/screeding and pile driving and the related effects of suspended sediments on water quality. These potential effects are being mitigated by the Project through the use of barges, which will be temporarily grounded offshore to reach the required water depths for access. The alternative would be a shore-based structure that would require a very large volume of sediment dredging to gain access, or a larger structure constructed perpendicular to shore to reach deeper depths, which could obstruct littoral transport of sediments for many years.

Because of the nature of the physical environment at the Project site and the location and configuration of the proposed structures, the overall direct and indirect effects are expected to be minimal and limited to the local area.

TABLE 4-9: SUMMARY OF THE LIKELY EFFECTS ON PHYSICAL OCEANOGRAPHY AND COASTAL WATER RESOURCES

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect
	Intensity	Scope / Magnitude	Duration	Context	
Drilling					
Activities causing diversion of normal surface flows at the three pad sites	Low to Medium	Local	Temporary to Long-Term	Activities could erosion of ice-wedge polygons and potential increase in coastal erosion	minor
Construction					
Installation of the bulkheads, dolphins, and Emergency Boat Launch Ramp.	Low to Medium	Local	Long-term	Permanent structures constructed in the nearshore environment and dredging of 1,500 cy of sediment may increase turbidity. Soils near the bulkheads could be susceptible to erosion.	minor
Operation					
Vessel operations	Low	Local	Temporary	Would cause a temporary increase in turbidity. Possible increase in ice ride-up and pile-up. Potential for accidental discharges of hydrocarbon products to marine surface waters.	minor

4.1.5 Climate

The Project will release GHG emissions, primarily carbon dioxide (CO_2), from the combustion of fossil fuels in each of the Project phases: drilling, construction, and operations. Additional GHG emissions may be released during the extraction of the fossil fuel resource. However, the Project intends to minimize potential fugitive GHG emissions by re-injecting the natural gas back into the Project field reservoir, i.e., enhanced oil recovery (EOR). GHG emissions can be estimated as part of the emission inventory for the Project construction and operating air quality permit applications. The anticipated GHG emissions from the Project will represent a negligible contribution to recent estimates for global, U.S., and Alaska GHG emission estimates. The global 2000 GHG emissions estimate was 41,755 million metric tons CO_2-equivalent (MMTCO_2e) (WRI 2009); the U.S. 2007 GHG emissions estimate was 7,150 MMTCO_2e (EPA 2009); and the Alaska 2005 GHG emissions estimate was 53 MMTCO_2e statewide for all sources and 15 MMTCO_2e for the oil and gas sector from fossil fuel combustion, transport, storage, and fossil fuel extraction activities (ADEC 2008). The U.S. Department of Interior MMS, recently projected GHG emissions from the proposed Beaufort Sea Lease Sales between 0.345–1.278 MMTCO_2e (MMS 2008). On a percentage basis, the MMS projected that the combined Beaufort Sea lease sale GHG emissions in terms of CO_2-equivalent measures are less than 0.02 percent of the nationwide total.

Conversely, future North Slope GHG emissions are expected to decrease because of expected declining oil and gas production. From 1977 to the end of 2006, North Slope developments produced 15.4 billion barrels (bbls) of oil and natural gas liquids (ADNR 2007). North Slope production peaked in 1998 at 2.0 million barrels (MMbbl) of oil per day, declining to its current rate of approximately 0.7 MMbl per day (ADOR 2009). ADEC projects the Alaska fossil fuel industry future fugitive GHG emissions from the extraction of fossil fuel resources will decrease from 4.9 MMTCO_2e in 1990 to 2.1 MMTCO_2e in 2020 (ADEC 2008). On a percentage basis, the Alaska 2005 oil and gas sector 15 MMTCO_2e GHG emissions were approximately 0.2 percent of the nationwide total and 0.04 percent of the global total.

The Project will have no direct effect as defined by 40 CFR 1508.8 on local climate or global climate change. In addition, the indirect effects to the physical, chemical, and biological environment associated with GHG emissions from the project will be negligible. Climate change is a global phenomenon, with effects caused by a number of factors, including the level of solar activity, natural cyclical variations in weather patterns, and the sum of global natural and anthropogenic GHG emissions. The Project GHG emissions will represent a negligible contribution to the U.S. and global GHG emissions. It would have an unquantifiable effect on climate change with respect to observed reduction in sea ice extent and sea ice thickness, increased permafrost degradation, increased coastal erosion, and other impacts to Arctic natural systems and the Alaska Natives and non-Native people. Table 4-10, at the end of this section, provides a summary of likely effects of the Project on climate.

4.1.5.1 Drilling

GHG emissions would occur during drilling activity from the operation of fossil fuel combustion equipment (generators, boilers, heaters, compressors, and turbines), venting and flaring, and transportation sources. The intermittent duration of the project drilling activity will have no direct effects as defined by 40 CFR 1508.8 and negligible indirect effects on climate change.

4.1.5.2 Construction

GHG emissions would occur during construction activity from the operation of fossil fuel combustion equipment, primarily from construction equipment and vehicle traffic. The three-to-four year construction activity GHG emissions will have no direct effects as defined by 40 CFR 1508.8 and negligible indirect effects on climate change.

4.1.5.3 Operations

GHG emissions would occur during facility operations from the operation of fossil fuel combustion equipment (gas turbines, gas-turbine-driven compressor and process heaters, generators, boilers, and heaters), safety flaring, and transportation sources. New turbines for the Project will have higher efficiency than existing North Slope Prudhoe Bay sources. The more efficient turbines are expected to lead to a reduction in fuel consumption (and GHG emissions) than existing North Slope Prudhoe Bay projects. Fuel gas for the Project equipment will have CO_2 removed before combustion, which will lead to a reduction in GHG emissions compared to other existing North Slope projects. In summary, the project operations will have no direct effects as defined by 40 CFR 1508.8 and negligible indirect effects on climate change.

4.1.6 Noise

The effects of Project-related noise emissions on the area surrounding the Project development may occur at the noise-sensitive land uses adjacent to the Project site, recreational areas, or wildlife habitats found in the region. Potential effects of noise on wildlife is addressed in Section 4.2.

4.1.6.1 Applicable Noise Standards and Regulations

The following discussion addresses relevant laws, ordinances, regulations, and standards (LORS) regarding noise emissions and exposure.

- National Environmental Policy Act (NEPA) (Title 42, United States Code, Part 4321, et seq. [42 USC 4321, et seq.]) (Public Law [PL] 91-190) (40 CFR § 1506.5]
- Noise Control Act of 1972 (42 USC 4910)
- EPA recommendations in “Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety”, National Technical Information Service, USEPA, Washington, D.C., March 1974.
- Federal Energy Regulatory Commission (FERC) Guidelines on Noise Emissions from Compressor Stations, Substations, and Transmission Lines (18 CFR 157.206(d)5).
- Occupational Safety and Health Administration (OSHA) Occupational Noise Exposure; Hearing Conservation Amendment (29 CFR § 1910.95).

TABLE 4-10: SUMMARY OF THE LIKELY EFFECTS ON CLIMATE

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect
	Intensity	Scope/Magnitude	Duration	Context	
Drilling					
Operation of fossil fuel combustion equipment (e.g., generators, boilers, heaters, compressors, and turbines), venting and flaring, and transportation sources	Low	Local to Regional	Temporary (intermittent duration)	Release of green house gasses to the atmosphere	None
Construction					
Operation of fossil fuel combustion equipment, primarily from construction equipment and vehicle traffic	Low	Local to Regional	Temporary (3- to 4-year construction activity)	Release of green house gasses to the atmosphere	None
Operation					
Extraction of the fossil fuel resource	Low	Local to Regional	Long-Term (duration of the Project)	Release of green house gasses to the atmosphere	None
Operation of fossil fuel combustion equipment (e.g., gas turbines, gas-turbine-driven compressor and process heaters, generators, boilers, and heaters), venting and flaring, and transportation sources	Low	Local to Regional	Long-Term (duration of the Project)	Release of green house gasses to the atmosphere	None

The State of Alaska does not have statewide noise regulations. Boroughs and cities may adopt a comprehensive plan or noise ordinance that establishes noise standards. The Project is located in the North Slope Borough (NSB), which has not adopted noise regulations applicable to the Project.

In the absence of state or local guidelines, the most relevant guidelines are federal guidelines provided by the EPA in "Information of Levels on Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety" (EPA 550/9 74 004). Although this document does not constitute EPA regulations or standards, it does identify safe levels of environmental noise exposure. These levels are provided without consideration for the technical or economic feasibility issues that may be associated with achieving these levels. In these guidelines, a Day-Night Average Noise Level (L_{dn}) of 55 A-weighted decibels (dBA) is recommended to maintain an "adequate margin of safety for areas of outdoor uses including residences and recreation areas" (EPA 1974). 55 dBA L_{dn} is equivalent to a constant, steady-state hourly Equivalent Noise Level (L_{eq})of 49 dBA. To assess potential noise effects on noise-sensitive land uses, the distance to the 49 dBA L_{eq} noise contours from the various pieces of mechanical equipment was determined. See Section 3.1.6.2 for an explanation of these noise measurements.

There are no applicable criteria for assessing noise on wildlife; therefore, as a conservative estimate for purposes of this analysis, a noise level of 35 dBA hourly L_{eq} will be used as a threshold.

With respect to national parks and recreational areas, noise impacts are not based on actual negative effects, but are assessed relative to level of expectation. In many of these areas, quiet is an expected attribute of the environment. For example, individuals exploring the Canning River do not have the same expectation of quiet as those hiking the serene trails of the Refuge in search of the natural quiet of the uninhabited wilderness.

Ambient noise measurement surveys in both Alaska and the Grand Canyon National Park have shown that ambient hourly noise levels in remote wilderness areas can range from 15–30 dBA L_{eq}. In areas with acoustic environments this low noise from outside sources can be detected by astute listeners at levels at or below the existing ambient level in the area. As a level to determine where the potential limit of noise propagation might be for the Project, a noise level of 15 dBA L_{eq} will be used as the assumed threshold of audibility.

To summarize, project-generated noise levels were estimated for the following:

- Distance to the 49 dBA hourly L_{eq} to assess impacts on noise-sensitive land uses
- Distance to the 35 dBA hourly L_{eq} to assess impacts on wildlife
- Distance to the 15 dBA hourly L_{eq} to assess threshold of audibility on recreational users

4.1.6.2 Drilling

During the drilling phase of the Project, noise will be generated by equipment associated with the drilling rig unit, which includes diesel engines, electric generators, traction motors, pumps, and compressors. These are expected to be the main sources of noise at every location where a drilling rig is established. Noise levels from the primary equipment from drilling operations have been calculated for the three noise metrics listed above, and the results are presented in Table 4-11. The noise levels listed in Table 4-11 are based upon reduction due to distance to the receptor only, and do not take into account any absorption because of ground cover. This is what is known as "hard site" conditions, which is considered absolute worst case projections. If the ground were covered with dense vegetation or a blanket of powdered snow, the absorption of the ground cover would reduce the distances substantially. This is what is known as "soft site" conditions. These levels also do not take into account the reduction to noise propagation due to wind, which can make a substantial change in the noise level over large distances. Receivers located upwind of the noise source will hear less noise from the Project than receivers located downwind.

TABLE 4-11: DISTANCE TO DRILLING NOISE LEVELS – HARD AND SOFT SITE

Noise	Hard Site		Soft Site	
Level	Distance	Distance	Distance	Distance
(dBA)	(feet)	(miles)	(feet)	(miles)
95.2	50	0.01	50	0.01
49.0	10,159	1.92	3,510	0.66
35.0	50,915	9.64	12,743	2.41
15.0	132,000	25.00	80,403	15.23

Notes:
dBA = A-weighted decibel scale

The noise level from the drilling rig is measured from the geometric center of the equipment associated with each rig. The further apart the equipment, the larger the noise footprint that is created around the rig site. The greater the distance a receiver is from the cluster of equipment, the more the cluster propagates as a single-point source. For the most part, drilling rig clusters propagate as individual point sources throughout the Project environs. Once the location of each of the proposed clusters is determined, the total noise footprint from all of the rig clusters can be determined for the region surrounding the total Project site.

Based on the worst-case calculations (hard site), the distance to the 49 dBA L_{eq} is approximately 2 miles. As there are no sensitive receptors within this distance, no impacts are expected. The distance to the 35 dBA L_{eq} is approximately 9 miles, so wildlife within this area may be disturbed. Effects of noise on wildlife are discussed in Section 4.2. The distance to the 15 dBA L_{eq} audibility threshold for recreational users is approximately 25 miles. Recreational users within this area may be able to detect slight increase in ambient noise due to drilling, but because drilling noise is temporary in nature, recreational users will not experience a permanent increase in noise.

4.1.6.3 Construction

Primary sources associated with construction are noise from on-site mechanical equipment used to prepare the site for operation, and noise from trucks, barges, and aircraft getting the equipment and materials on site. These sources will include trucks, barges, aircraft, and other vehicle traffic. Materials will be transported by truck over the ice road using Rolligons or other tundra travel equipment. Barges will be used during open water season to transport drilling supplies and equipment, fuel, and to remove drill waste. Personnel and small equipment will be transported by aircraft and helicopters between Deadhorse and the Project area.

These effects are likely to be short-term effects lasting the duration of the construction phase (spanning three winter seasons). Summer construction activities are fewer in number and should therefore have potentially fewer effects.

Pile Driving Noise

A pier will be constructed to accommodate the use of barges to deliver equipment to the Project site. The pier will be constructed during the winter construction season and will be built on piles. Pile driving is expected to generate airborne noise, but because the piles will be driven when the water is frozen, there will be no marine receptors susceptible to it.

Airborne sound power level data generated by several different types of pile-driving activities was collected and the results are presented in Table 4-12. These data, compiled by the Environmental Protection Department for the Government of Hong Kong, list the airborne sound power level for a diesel hammer impacting pre-stressed concrete piles, which is the combination of piles and driver expected to be used for this Project.

The data listed in Table 4-12 show a range of sound power levels based on hammer type and the type of pile being driven. Hydraulic hammers are the most common type. The maximum noise level for a hydraulic hammer is 129 dBA, which translates to a maximum sound pressure level of 97.4 dBA at a distance of 50 feet (15 meters) from the driver, and a maximum sound pressure level (L_{max}) of 91.4 dBA at a distance of 100 feet (30 meters) from the driver. The distances to the noise level contours associated with the potential impact and detectability thresholds were calculated, and the results are presented in Table 4-13 for both hard site and soft site terrain conditions.

Based on the calculations, noise-sensitive land uses within 2.5 miles of pile driving may experience sound levels above the EPA-threshold. As there are no residences within this distance, no impacts are expected. Furthermore, noise from pile driving is considered temporary in duration.

TABLE 4-12. SOUND POWER LEVELS FOR PERCUSSIVE PILING

Piling Method and Pile Type	Sound Power Level (dBA)
Diesel hammer driving pre-stressed concrete pile	128
Diesel hammer driving steel pile	132
Diesel hammer driving steel sheet pile	132
Drop hammer driving concrete pile	116
Drop hammer driving steel pile	126
Drop hammer driving steel sheet pile	129
Hydraulic hammer (double acting) driving pre-stressed concrete pile	126
Hydraulic hammer (double acting) driving steel pile	129
Hydraulic hammer (double acting) driving steel sheet pile	129
Hydraulic hammer (single acting) driving pre-stressed concrete pile	122
Hydraulic hammer (single acting) driving steel pile	126
Hydraulic hammer (single acting) driving steel sheet pile	126
Internal drop hammer	113
Pneumatic or steam hammer (double acting) driving steel sheet pile	135
Pneumatic or steam hammer (single acting) driving steel pile	130

Environmental Protection Department - Government of Hong Kong

Notes:
dBA = A-weighted decibel.

TABLE 4-13: DISTANCE TO PILE DRIVING NOISE LEVELS – HARD AND SOFT SITE

Noise	Hard Site		Soft Site	
Level	**Distance**	**Distance**	**Distance**	**Distance**
(dBA)	**(feet)**	**(miles)**	**(feet)**	**(miles)**
97.4	50	0.01	50	0.01
49.0	13,182	2.50	4,323	0.82
35.0	66,066	12.51	15,696	2.97
15.0	660,660	125.13	99,032	18.76

Notes:
dBA = A-weighted scale

Based on the worst-case calculations (hard site), the distance to the 49 dBA L_{eq} is approximately 2.5 miles. As there are no sensitive receptors within this distance, no impacts are expected. The distance to the 35 dBA L_{eq} is approximately 12 miles, so wildlife within this area may be disturbed. Effects of noise on wildlife are discussed in Section 4.2. The distance to the 15 dBA L_{eq} audibility threshold for recreational users is approximately 125 miles. However, noise from pile driving at this distance will likely not be audible over ambient conditions. Furthermore, pile driving is expected to occur over a few-week period so impacts are considered temporary in nature and short-term in duration.

General Construction

Projected noise levels and distances to the noise level contours associated with the potential impact and detectability thresholds were calculated and the results are presented in Table 4-14 for both hard site and soft site terrain conditions for general construction activities. Based on the worst-case (hard site) calculations, the distance to the 49 dBA L_{eq} is less than 1 mile. As there are no noise-sensitive receptors within this distance, no impacts are expected. The distance to the 35 dBA L_{eq} is approximately 3 miles, so wildlife within this area may be disturbed. The distance to the 15 dBA L_{eq} audibility threshold is approximately 30 miles, so recreational users within this area may be able to detect construction noise over ambient conditions. However, because of the distance, detection may only be possible under the best of conditions and is not expected to disturb recreational users over the long-term.

TABLE 4-14: DISTANCE TO CONSTRUCTION EQUIPMENT NOISE LEVELS – HARD AND SOFT SITE

	Reference	Distance to 49 dBA		Distance to 35 dBA		Distance to 15 dBA	
Equipment Description	**Noise Level (50 feet)**	**Hard Site (feet)**	**Soft Site (feet)**	**Hard Site (feet)**	**Soft Site (feet)**	**Hard Site (feet)**	**Soft Site (feet)**
Rolligon	85	3,155	1,377	15,811	5,000	158,114	31,548
Snowblower	85	3,155	1,377	15,811	5,000	158,114	31,548
Dozer D6	82	2,233	1,045	11,194	3,793	111,936	23,932
Dozer D8	82	2,233	1,045	11,194	3,793	111,936	23,932
Grader 12 H	85	3,155	1,377	15,811	5,000	158,114	31,548
Grader 12 H	85	3,155	1,377	15,811	5,000	158,114	31,548
Chipper on loader	85	3,155	1,377	15,811	5,000	158,114	31,548
Misc. Tanks, Pumps & gen sets	76	1,119	601	5,610	2,183	56,101	13,771
300 Barrel tanker	85	3,155	1,377	15,811	5,000	158,114	31,548
B-70 & End Dump Gravel Hauler(empty)	85	3,155	1,377	15,811	5,000	158,114	31,548
Dump Truck	76	1,119	601	5,610	2,183	56,101	13,771
Manitowoc 4600 Crane	83	2,506	1,145	12,559	4,159	125,594	26,240
Transformer	85	3,155	1,377	15,811	5,000	158,114	31,548

Notes:
dBA = A-weighted scale

4.1.6.4 Operations

Noise sources existing during operations will include: diesel drilling rig generators; diesel generators located at the Central Processing Facility (CPF) to provide power during the first few years of construction activities until fuel gas is available to supply the CPF main power generation; drilling rig support equipment such as boilers and heaters; gas-turbine-driven generators; and mobile sources, including vehicles, equipment (e.g., cranes, etc.), marine vessels (in summer, if required), helicopters, and airplanes used to transport equipment, materials, and personnel to and from the site. To ensure the integrity of the airstrip, pads, and roads, routine inspection and maintenance will be required. Road maintenance will be performed as needed using equipment such as motor graders, front-end loaders, backhoes, and water tankers for dust control. During winter months, snow removal activities will be conducted on an ongoing basis. Personnel and equipment such as front-end loaders and motor graders will be available to handle the snow removal requirements at the Central Pad, remote pads, airstrip, and other gravel-filled infrastructure.

Noise generated during operations is expected to be less than noise produced during drilling and construction phases. Detailed calculations were not performed for operational noise, as noise levels will vary throughout the season. As a conservative estimate, noise levels from operation are considered to be similar to general construction. Based on the worst-case (hard site) calculations, the distance to the 49 dBA L_{eq} is less than 1 mile. As there are no noise-sensitive receptors within this distance, no impacts are expected. The distance to the 35 dBA L_{eq} is approximately 3 miles, so wildlife within this area may be disturbed. The distance to the 15 dBA L_{eq} audibility threshold is approximately 30 miles, so recreational users within this area may be able to detect operational noise over ambient. However, because of the distance, detection may only be possible under the best of conditions and is not expected to disturb recreational users over the long-term.

4.1.6.5 Conclusion

The overall effect of noise during drilling and construction will be minor. During operation of the Project noise generated by compressors and other equipment could have a moderate effect. Noise effects are summarized in Table 4-15.

TABLE 4-15: SUMMARY OF THE LIKELY NOISE EFFECTS

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect
	Intensity	Scope / Magnitude	Duration	Context	
Drilling					
Gravel Mining and Placement and Ice Roads/Pads	Medium	Local	Temporary during use of heavy equipment	No sensitive land uses within area of potential impact.	Minor
Drilling rigs and associated heavy equipment	Medium	Local	Temporary during use of heavy equipment and drilling	No sensitive land uses within area of potential impact. Recreational users may be able to detect noise in the Refuge.	Minor
Construction					
Gravel Mining and Placement	Medium	Local	Permanent	No sensitive land uses within area of potential impact.	Minor
Ice Roads and Ice Pads	Medium	Local	Temporary	No sensitive land uses within area of impact.	Minor
Pile Driving	High	Local	Temporary	No sensitive land uses within area of impact. Recreational users will likely be able to detect pile driving noise in the Refuge.	Minor
Heavy equipment operations	Medium	Local	Temporary	No sensitive land uses within area of impact. Recreational users may be able to detect construction equipment in the Refuge under certain conditions.	Minor
Traffic	Low	Local	Temporary to Long-term	No sensitive land uses within area. Recreational users	Minor

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect
	Intensity	Scope / Magnitude	Duration	Context	
				not likely to detect traffic noise.	
Operation					
Compressors, turbines, etc.	Medium	Local	Permanent	No sensitive land uses within impact area. Recreational users may be able to detect operational noise.	Moderate
Traffic to/from facility (including air, barge, road)	Medium	Regional	Temporary for each vehicle, vessel, aircraft trip.	No sensitive land uses within impact area. Recreational users may hear aircraft.	Minor

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Marine Benthos

As described in Section 3.2.1, the benthic community of Lion Bay is primarily composed of infaunal and epifaunal invertebrates similar to other Beaufort Sea coastal lagoons and bays. Because depths within the lagoon do not exceed 20 feet (6 meters), the community is likely characterized by low density and diversity, which is characteristic of the nearshore zone of the Beaufort Sea (Carey and Ruff 1977; Carey 1978). The shorefast ice present in the nearshore zone (at depths less than 6 feet) is dominated by motile opportunistic species that can and normally do re-colonize annually.

The potential direct and indirect effects discussed here include mortality, habitat loss, disturbance, and habitat alteration. Table 4-16 summarizes the potential effects on the benthic community.

4.2.1.1 Direct and Indirect Effects of Drilling

Drilling activities at the Project are all onshore and will not affect the benthic community or benthic habitat of the Project area.

4.2.1.2 Direct and Indirect Effects of Construction

To facilitate barge offloading of sealift modules, an onshore high bulkhead and five offshore mooring dolphins (each dolphin consists of a set of three pilings driven into the seafloor) will be installed. The high bulkhead will be located above MHW and will be constructed to an open cell design with gravel backfill for the transition to the Central Pad finish grade. Three temporarily grounded and ballasted barges will be used to construct a causeway off the high bulkhead for marine offload operations. The barges will be temporarily grounded for approximately two weeks during the open water season. This method will allow direct transport of large modules by sealift from their place of manufacture to the Project. This system eliminates the necessity of a more permanent structure, such as a gravel dock.

A second bulkhead, the low bulkhead, will be constructed adjacent to the high bulkhead. The low bulkhead will be used to facilitate offloading of shallow draft barges and landing craft. Construction techniques are the same as the high bulkhead summarized above. It will be constructed above MHW and connected to the Central Pad finished grade.

An emergency response boat ramp will be constructed on the east side of the Central Pad to support oil spill response efforts by Alaska Clean Seas. The boat launch will be approximately 16-feet-wide by 150-feet-long (all above MHW) and will have gangway pilings below MHW that cover less than 0.1 acre of benthic habitat.

Small quantities of seafloor material will need to be removed from in front of the Central Pad bulkheads to allow access by the barge up to the bulkhead. The screeded and dredged area will be approximately 150-feet-wide and 400-feet-long, or approximately 1.4 acres. On the basis of the bathymetry, it is estimated that up to 1,500 cy of excess material may need to be removed. This bottom material will be placed along designated shoreline locations, above MHW, covering an area approximately 20-feet-wide by 1,015-feet-long by 2-feet-deep.

Habitat Alteration and Loss

Habitat alteration and loss because of construction activities may result from disturbance to the seafloor from screeding and dredging, installation of the mooring dolphins, grounded and ballasted barge placement, installation of the emergency response boat ramp gangway pilings, and barge movement. The screeded and dredged area will be located in front of the high bulkhead and will be approximately 1.4 acres. The mooring dolphins will cover less than 0.1 acre of benthos habitat, the grounded and ballasted barges will cover approximately 2.9 acres of benthos habitat, and the emergency response boat ramp gangway pilings will cover approximately 0.1 acre.

Seafloor screeding and dredging may result in both habitat alteration and mortality of the benthic organisms present. The habitat alteration and loss would be temporary and habitat will be open to re-colonization by benthic organisms once the grooming is complete. Propeller wash from operating vessels may also cause some alteration of the sediments, as well as some mortality to associated organisms; this habitat alteration and loss will be temporary, occurring only during vessel operation.

The mooring dolphins and emergency response boat ramp will remain for the life of the Project. These will potentially affect 0.1 acre each, which is a very small amount of benthos habitat compared to the habitat that is available for benthos currently and is not expected to have population-level consequences.

The grounded and ballasted barges will only be in place for approximately two weeks, so the habitat potentially affected by the facility will be short-term. This habitat will be unavailable to benthic organisms during a two week period while barges are being unloaded; however, once the grounded and ballasted barges are removed, the habitat will once again be available for colonization by benthic organisms. Overall, potential habitat alteration and loss related to construction is minor and localized.

As discussed in Section 3.2.1 this area is dominated by motile opportunistic species that re-colonize annually because of ice scour. Because some of the area affected by the grounded and ballasted barges and the dredging footprint overlap, dredging does not add significant additional potential effects to benthos habitat. Further, removed material will be placed onshore and will not affect any other benthic habitat. Given the localized area in which potential habitat alteration and loss effects related to construction may occur, the effects on benthos are anticipated to be minor.

Mortality

Limited mortality may take place as a result of construction activities and in the unlikely event of an oil spill. The direct mortality from seafloor screeding and dredging, and placement of the grounded and ballasted barges on the sea floor, is only scheduled to take place over short period of time each summer for up to three years, and is therefore considered a temporary Project effect. The benthic community would be expected to recover fully during the following summer season. The screeded and dredged areas will be small relative to the surrounding habitat, and therefore the number of benthic organisms affected would likewise be relatively small.

A large oil spill would have short-term effects on epifaunal organisms and longer-term effects on infaunal organisms that live in the sediments. The majority of oil-spill-related mortality would take place over a one-year period, but some fraction of the oil spilled would persist in the sediments for 5–10 years (MMS 2002). While the potential effects of oil spills are very high, the likelihood that an oil spill will take place is relatively low. The mortality of benthic organisms as a result of an accidental oil spill during construction is therefore considered an unlikely and minor potential effect.

Disturbance

Disturbance to benthic organisms could be caused by alteration of flow patterns while the grounded and ballasted barges are in place, increased turbidity associated with seafloor screeding and dredging, and increased propeller wash effects from boat traffic. Flow pattern changes could cause deposition (or erosion) of sediment and organic material in the vicinity of the grounded and ballasted barges; however, this will likely be a very small change in circulation patterns and a temporary and localized effect.

Potential increases in turbidity would likely 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 break-up (USACE 1987; Britch et al. 1983). On the basis of results of a 5-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 erosion patterns that may result from the presence of the proposed temporary grounded and ballasted barges and barging activities. Further, all turbidity increases would be of temporary duration. The potential disturbance to benthos as a result of construction is considered minor because of the temporary and localized nature of the potential effects.

4.2.1.3 Direct and Indirect Effects of Operations and Maintenance

The grounded and ballasted barges and associated seafloor screeding and dredging will take place only during construction activities, which will eliminate many of the potential effects on benthos from the long-term operations and maintenance of the Project. Shallow-draft barges will continue to use the low bulkhead during the open water season, and the potential for an accidental oil spill will remain throughout the life of the Project. Both the low bulkhead, high bulkhead, and the emergency response boat ramp and associated gangway will be present for the life of the Project.

Habitat Alteration and Loss

The emergency response boat ramp gangway pilings may potentially alter benthos habitat through direct occupation of the habitat. Shallow-draft barge traffic and associated propeller wash may also alter benthic habitats. Potential effects from barge traffic will be short-term and localized to the shallowest habitats near the low bulkhead. Habitat is not a limiting factor for the benthos population and the potential habitat alteration and loss associated with operations is not expected to have effects on the benthos community.

Mortality

With the exception of a potential oil spill, there is no anticipated benthos mortality related to operations. During operations there will be very limited barge fuel transport, because operational equipment will be operating with natural gas produced on site. An oil spill could potentially have minor to major effects on the benthic community in Lion Bay, depending on the severity of the oil spill. However, the likelihood of a major oil spill is low. The benthic community affected would likely fully recover over a 1–5-year period (MMS 2002) and would not suffer population-level effects. Therefore, the likelihood of the event and the temporary duration (fast recovery time of the population) make this potential effect minor.

Disturbance

Limited disturbance may potentially take place as a result of shallow draft-barge traffic and associated propeller wash. The disturbance will be limited to the seasonal shallow-draft barge trips and is expected to have short-term effects on the benthos community in the area. The potential disturbance effects on benthos related to operations are anticipated to be short-term, localized, and minor.

TABLE 4-16: POTENTIAL EFFECTS ON MARINE BENTHOS

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Drilling				
Habitat Alteration and Loss	None	None	None	None
Construction				
Habitat Alteration and Loss	Grounded and ballasted barges Emergency response boat ramp Seafloor screeding and dredging	Local	Temporary	Minor
Mortality	Grounded and ballasted barges Emergency response boat ramp Seafloor screeding and dredging Accidental Oil Spill	Local	Temporary	Minor
Disturbance	Changes in circulation and sediment deposition from grounded and ballasted barges Increased barge traffic that may result in increased turbidity Seafloor screeding and dredging Grounded and ballasted barge removal	Local	Temporary	Minor
Operations				
Mortality	Coastal barge landing ramp Emergency response boat ramp	Long-term	Temporary	Minor

4.2.2 Vegetation and Wetlands

As described in Section 3.2.2 approximately one-third of the Project area is covered by water. The remaining two-thirds of the Project area are dominated by moist sedge, dwarf shrub/wet sedge tundra complexes (Type III vegetation classes) and moist sedge, dwarf shrub tundra (Type V vegetation classes). Each phase of the Project entails different activities or components with the potential to affect surrounding vegetation and wetlands.

4.2.2.1 Drilling

Drilling is currently occurring at the existing Central Pad. Initial access may involve ice pads and ice roads, potential effects of which are described in subsection Roads and Pads. Gravel roads would be built during the construction phase of the Project; potential effects of gravel placement for pads and roads are described in subsection Gravel Placement. Drilling at West Pad and East Pad will happen after completion of the gravel roads and pads.

Wetlands and vegetation may be disturbed during the drilling phase of the Project, through the indirect effects of gravel placement (fugitive dust, impoundments, thermokarst from existing Central Pad), and the direct effects of ice roads and/or pad construction, effects of water removal, and effects of accidental spills and leaks. The overall effect of disturbance, however, is anticipated to be minor, because of the relatively small area affected in relationship to the general extent of wetlands and affected vegetation types in the Project area, the relative function and value of wetlands affected, the unlikely occurrence of a large spill to vegetation and wetlands, and because all drilling will take place on gravel or ice pads. The environmental consequences of disturbance by gravel or ice roads and pads on vegetation and wetlands are fully addressed in the following section.

4.2.2.2 Construction

During the construction phase of the Project, approximately 300 acres of tundra will be covered or disturbed by gravel pads, gravel roads, a gravel airstrip, and a gravel mine and associated gravel storage pad (Table 4-17); additionally, approximately 65 acres of tundra will be covered by ice pads for temporary overburden stockpiles during the one winter of gravel mining operations (Table 4-18). Over 33 miles (53 kilometers) of pipeline will be installed by using ice roads to access the pipeline right-of-ways (Table 4-18). Both disturbance and mortality are the anticipated direct and indirect effects to vegetation and wetlands during the construction phase of the Project (Table 4-19).

Vegetation loss will be incurred by the direct effects of gravel placement for roads and pads, by ice roads and pads, by gravel mine development, and by accidental spills and leaks. While the magnitude of effect associated with each component may vary slightly in geographic and temporal extent, the overall effect of loss to vegetation and wetlands in the construction phase of the Project is anticipated to be moderate. Although vegetation and wetland types lost to mortality are relatively common in the Project area, much of the loss anticipated to occur in association with construction will have long-term effects on local vegetation and wetlands (i.e., placement of gravel fill will result in long-term loss of or substantial modification to these communities).

Disturbance to wetlands and vegetation will be associated with indirect effects of gravel placement (impoundments, thermokarst, and dust fallout from gravel roads and pads) and directly by water removal and contamination from leaks and spills. While the magnitude of disturbance associated with each component may vary slightly in geographic and temporal extent, the overall effect of disturbance to vegetation and wetlands in the construction phase of the Project is anticipated to be minor. This is because of the generally local nature of the effects, the prevalence of wetlands and affected vegetation types in the Project area, the relative function and value of affected wetlands, and the temporary nature of anticipated disturbance effects.

Direct and indirect effects from each activity are described in detail in the following sections.

Gravel Placement

Vegetation loss is a direct effect anticipated wherever gravel fill is placed. Gravel placement for roads, pads, the airstrip and helipad, and small ancillary pads constructed for the Project will cover approximately 240 acres of tundra (Table 4-17). The vegetation types that would be most affected by gravel placement are wet sedge/moist sedge, dwarf shrub tundra complex (IIId) and moist sedge, dwarf shrub tundra (Va); together, these two types comprise more than 50 percent of the gravel placement footprint.

The majority of the Project area is wetland (see Chapter 3, Affected Environment), thus avoidance of wetland fill is not practicable. Instead, the Project has minimized effects to vegetation and wetlands by using existing gravel fill at Central, East, and C-1 pads; avoiding lake habitat; and proposing to use sufficient fill volumes to preserve the thermal integrity of underlying permafrost. Mitigation may be achieved by reducing the footprint of gravel fill areas and by avoiding high-value wetlands. The effects of gravel cover are long-term; vegetation recovery is slow following removal or remediation of gravel fill (Johnson 1987; Walker et al. 1987).

TABLE 4-17: ESTIMATED POINT THOMSON PROJECT FACILITY FOOTPRINTS BY VEGETATION TYPE IN ACRES (INTERPRETED FROM AERIAL PHOTOGRAPHY BY LGL 1993–1999 AND OASIS 2009)

Vegetation Type	Wetland Type	Airstrip[1]	Airstrip Road	Central Pad[2]	Central Pad Road	Central Pad Bulkheads	East Pad	East Pad Road	West Pad	West Pad Road
Ia: Water (ponds, lakes, rivers, streams, saltwater)	E1UBL, R1UBV, R2UBH, R3UBH, L1UBH, L2UBH, PUBH	0.0	0.0	1.2	0.1	0.1	0.5	0.3	0.2	0.2
IIIb: Wet Graminoid Tundra (wet saline tundra, saltmarsh)	E2EM1N, E2EM1P	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.5	0.0
IXh: Wet Barren/Wet Sedge Tundra Complex (barren/saline tundra complex, saltmarsh)	E2USN, E2USP, E2EM1P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXi: Dry Barren/Forb, Graminoid Complex (saline coastal barrens)	PSS/EM1B	0.0	0.0	2.5	0.0	0.3	4.6	0.0	2.6	0.4
IIb: Aquatic Graminoid Tundra (emergent vegetation)	L2EM2H, PEM1H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IId: Water/Tundra Complex (interconnected ponds with emergent vegetation)	L2UB/EM2H, PUB/EM2H, PUB/EM1H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IIIa: Wet Sedge Tundra	PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	9.5	0.0	0.0	0.5	0.1	0.0	0.3
IIIc: Wet Sedge Tundra/Water Complex (interconnected ponds with no emergent vegetation)	L2EM2/UBH, PEM1/UBH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
IIId: Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	28.7	0.3	1.4	0.3	0.0	0.0	17.0	0.0	3.2
IIIe: Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.5
IVa: Moist Sedge, Dwarf Shrub/Wet Graminoid Complex (moist patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	18.8	1.9	0.0	1.9	0.0	0.0	4.8	7.6	7.9
Va: Moist Sedge, Dwarf Shrub Tundra	PSS/EM1B	0.0	0.0	14.1	8.6	0.0	6.5	5.2	5.6	18.0
Ve: Moist Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B	0.0	0.0	1.2	2.2	0.0	0.0	2.4	0.0	3.7
Vb: Moist Tussock Sedge, Dwarf Shrub Tundra	PEM/SS1B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vc: Dry Dwarf Shrub, Crustose Lichen Tundra (Dryas tundra, pingos)	Non-Wetland	0.0	0.0	0.0	3.3	0.0	1.3	1.3	1.5	1.9
Vd: Dry Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra)	Non-Wetland and PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXb: Dry Barren/Dwarf Shrub, Forb Grass Complex (forb-rich river bars)	Non-Wetland and PSS/EM1A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
IXc: Dry Barren/Forb Complex (river bars in active channels)	PEM1/USD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXe: Dry Barren/Grass Complex	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXf: Dry Barren/Dwarf Shrub, Grass Complex (sand dune steppe)	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xa: River Gravels	R2USC, R3USC	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0
XIa: Wet Mud	L2USD, PUSD	0.4	0.0	0.1	0.0	0.0	1.7	0.1	0.0	0.1
XIc: Bare Peat	L2USD, PUSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xc: Barren Gravel Outcrops	Non-Wetland/Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xe: Gravel Roads and Pads	Non-Wetland/Unknown	0.0	0.0	16.6	0.0	0.4	2.5	0.0	0.0	0.0
Total Acres		47.9	2.2	48.6	16.4	1.2	17.7	31.3	18.2	36.3

TABLE 4-17 (CONT): ESTIMATED POINT THOMSON PROJECT ICE ROAD FOOTPRINTS BY VEGETATION TYPE IN ACRES (INTERPRETED FROM AERIAL PHOTOGRAPHY BY LGL 1993–1999 AND OASIS 2009)

Vegetation Type	Wetland Type	C-1 Pad	C-1 Pad Road	Water Source Pad	Water Source Road	Gravel Storage Pad	Gravel Mine	Gravel Mine Road[3]	Temporary Inorganic Overburden Stockpile[4]	Temporary Organic Overburden Stockpile[4]	Sub-total	Percent of Total
Ia: Water (ponds, lakes, rivers, streams, saltwater)	E1UBL, R1UBV, R2UBH, R3UBH, L1UBH, L2UBH, PUBH	0.0	0.0	0.0	0.0	0.0	2.5	0.0	6.1	0.0	11.4	3.1
IIIb: Wet Graminoid Tundra (wet saline tundra, saltmarsh)	E2EM1N, E2EM1P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.3
IXh: Wet Barren/Wet Sedge Tundra Complex (barren/saline tundra complex, saltmarsh)	E2USN, E2USP, E2EM1P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXi: Dry Barren/Forb, Graminoid Complex (saline coastal barrens)	PSS/EM1B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6	2.9
IIb: Aquatic Graminoid Tundra (emergent vegetation)	L2EM2H, PEM1H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IId: Water/Tundra Complex (interconnected ponds with emergent vegetation)	L2UB/EM2H, PUB/EM2H, PUB/EM1H	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0
IIIa: Wet Sedge Tundra	PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	2.9
IIIc: Wet Sedge Tundra/Water Complex (interconnected ponds with no emergent vegetation)	L2EM2/UBH, PEM1/UBH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
IIId: Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	10.7	25.7	1.9	40.2	8.8	138.1	37.7
IIIe: Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.5
IVa: Moist Sedge, Dwarf Shrub/Wet Graminoid Complex (moist patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.5	0.0	0.0	0.0	2.4	0.0	0.9	0.0	46.8	12.8
Va: Moist Sedge, Dwarf Shrub Tundra	PSS/EM1B	0.0	0.1	0.0	0.0	0.0	24.2	2.4	0.0	7.1	91.7	25.0
Ve: Moist Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B	0.0	0.0	0.6	0.3	0.0	4.0	0.0	0.0	2.2	16.6	4.5
Vb: Moist Tussock Sedge, Dwarf Shrub Tundra	PEM/SS1B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vc: Dry Dwarf Shrub, Crustose Lichen Tundra (Dryas tundra, pingos)	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	9.7	2.7
Vd: Dry Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra)	Non-Wetland and PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXb: Dry Barren/Dwarf Shrub, Forb Grass Complex (forb-rich river bars)	Non-Wetland and PSS/EM1A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
IXc: Dry Barren/Forb Complex (river bars in active channels)	PEM1/USD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXe: Dry Barren/Grass Complex	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXf: Dry Barren/Dwarf Shrub, Grass Complex (sand dune steppe)	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xa: River Gravels	R2USC, R3USC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.1
XIa: Wet Mud	L2USD, PUSD	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.0	3.3	0.9
XIc: Bare Peat	L2USD, PUSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xc: Barren Gravel Outcrops	Non-Wetland/Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xe: Gravel Roads and Pads	Non-Wetland/Unknown	4.4[6]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.9[6]	6.5[6]
Total Acres		4.4	0.7	0.6	0.3	10.7	59.3	4.8	47.7	18.1	366.4[4,5]	

Notes:
1 Airstrip estimated footprint includes Helipad, Navigational Aid (NavAid) Pads, NavAid Roads, and ancillary NavAid vertical support members (VSMs).
2 Central Pad estimated footprint includes emergency response boat launch.
3 Gravel Mine Road includes Stream Diversion Road
4 Inorganic and organic overburden stockpiles will be placed on ice pads during gravel mining. Gravel mining is anticipated to take one winter season, after which overburden will be returned to the mine site.
5 Total does not include the dredge disposal area, cable trenching, or the estimated 0.6 acres of pipeline and navigational aid VSM footprints whose locations are to be determined in final engineering.
6 Previously permitted gravel fills for exploration pads.

TABLE 4-18: ESTIMATED POINT THOMSON PROJECT ICE ROAD FOOTPRINTS BY VEGETATION TYPE IN ACRES (INTERPRETED FROM AERIAL PHOTOGRAPHY BY LGL 1993–1999 AND OASIS 2009)

Vegetation Type	Wetland Type	Export Pipeline and West Gathering Lines Ice Road	West Pad Road Ice Road	Export Pipeline and West Gathering Line Ice Road	Central Pad Road to Water Source Ice Road	East Gathering Line Ice Road	Export Pipeline Ice Road	Sub-total	Percent of Total
Ia: Water (ponds, lakes, rivers, streams, saltwater)	E1UBL, R1UBV, R2UBH, R3UBH, L1UBH, L2UBH, PUBH	0.6	1.0	22.6	3.5	15.0	33.1	75.8	15.9
IIIb: Wet Graminoid Tundra (wet saline tundra, saltmarsh)	E2EM1N, E2EM1P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXh: Wet Barren/Wet Sedge Tundra Complex (barren/saline tundra complex, saltmarsh)	E2USN, E2USP, E2EM1P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXi: Dry Barren/Forb, Graminoid Complex (saline coastal barrens)	PSS/EM1B	0.0	0.0	0.0	0.6	0.1	0.0	0.7	0.1
IIb: Aquatic Graminoid Tundra (emergent vegetation)	L2EM2H, PEM1H	0.0	0.5	1.4	0.0	0.1	1.4	3.4	0.7
IId: Water/Tundra Complex (interconnected ponds with emergent vegetation)	L2UB/EM2H, PUB/EM2H, PUB/EM1H	0.0	0.0	0.8	0.0	0.2	0.0	1.0	0.2
IIIa: Wet Sedge Tundra	PEM1B, PEM1E, PEM1H, PEM1F	0.0	1.7	2.6	2.3	2.1	3.3	12.0	2.5
IIIc: Wet Sedge Tundra/Water Complex (interconnected ponds with no emergent vegetation)	L2EM2/UBH, PEM1/UBH	0.0	0.0	0.0	0.0	0.0	4.7	4.7	1.0
IIId: Wet Sedge/Moist Sedge, Dwarf Shrub Tundra Complex (wet patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	1.1	1.6	8.5	10.8	5.9	18.1	46.0	9.6
IIIe: Wet Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.9	1.5	1.3	0.0	4.2	0.0	7.9	1.7

Vegetation Type	Wetland Type	Export Pipeline and West Gathering Lines Ice Road	West Pad Road Ice Road	Export Pipeline and West Gathering Line Ice Road	Central Pad Road to Water Source Ice Road	East Gathering Line Ice Road	Export Pipeline Ice Road	Sub-total	Percent of Total
IVa: Moist Sedge, Dwarf Shrub/Wet Graminoid Complex (moist patterned ground complex)	PSS/EM1B, PEM1B, PEM1E, PEM1H, PEM1F	0.0	10.4	16.3	0.2	8.2	75.1	110.3	23.1
Va: Moist Sedge, Dwarf Shrub Tundra	PSS/EM1B	1.5	20.5	10.8	14.5	25.1	62.7	135.0	28.3
Ve: Moist Graminoid, Dwarf Shrub Tundra/Barren Complex (frost-scar tundra complex)	PSS/EM1B	0.0	1.9	4.9	0.7	1.9	28.4	37.8	7.9
Vb: Moist Tussock Sedge, Dwarf Shrub Tundra	PEM/SS1B	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vc: Dry Dwarf Shrub, Crustose Lichen Tundra (Dryas tundra, pingos)	Non-Wetland	0.5	2.6	4.3	3.1	4.7	3.6	18.9	4.0
Vd: Dry Dwarf Shrub, Fruticose Lichen Tundra (dry acidic tundra)	Non-Wetland and PEM1B, PEM1E, PEM1H, PEM1F	0.0	0.0	0.0	0.0	0.0	5.2	5.2	1.1
IXb: Dry Barren/Dwarf Shrub, Forb Grass Complex (forb-rich river bars)	Non-Wetland and PSS/EM1A	0.0	0.2	0.0	0.0	0.0	4.1	4.4	0.9
IXc: Dry Barren/Forb Complex (river bars in active channels)	PEM1/USD	0.0	0.0	0.0	0.0	0.0	1.1	1.1	0.2
IXe: Dry Barren/Grass Complex	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IXf: Dry Barren/Dwarf Shrub, Grass Complex (sand dune steppe)	Non-Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xa: River Gravels	R2USC, R3USC	0.0	0.0	0.1	0.8	0.0	0.7	1.6	0.3
XIa: Wet Mud	L2USD, PUSD	0.4	0.3	1.3	0.1	2.0	0.3	4.5	0.9
XIc: Bare Peat	L2USD, PUSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xc: Barren Gravel Outcrops	Non-Wetland/Unknown	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Vegetation Type	Wetland Type	Export Pipeline and West Gathering Lines Ice Road	West Pad Road Ice Road	Export Pipeline and West Gathering Line Ice Road	Central Pad Road to Water Source Ice Road	East Gathering Line Ice Road	Export Pipeline Ice Road	Sub-total	Percent of Total
Xe: Gravel Roads and Pads	Non-Wetland/Unknown	0.0	0.0	0.0	7.0	0.0	0.0	7.0	1.5
Total Acres		4.9	42.2	75.0	43.7	69.7	241.8	477.4	100.0

TABLE 4-19: SUMMARY OF LIKELY EFFECTS ON VEGETATION AND WETLANDS

Project Phase Assessment Criteria	Activity	Geographic Scope	Duration	Overall Effect
Drilling				
Mortality/Loss	Ice roads/pads Accidental spills and leaks	Local	Temporary	Minor
Disturbance	Indirect effects of gravel fill (fugitive dust, impoundments, thermokarst) Ice roads/pads Water removal Accidental spills and leaks	Local	Temporary	Minor
Construction				
Mortality/Loss	Gravel placement (including indirect effects such as fugitive dust) Ice roads/pads Gravel mine development Accidental spills and leaks	Local	Long-Term	Moderate
Disturbance	Indirect effects of gravel fill (fugitive dust, impoundments, thermokarst) Ice roads/pads Water removal Accidental spills and leaks	Local	Temporary	Minor
Operations				
Mortality/Loss	Indirect effects of gravel fill (fugitive dust) Accidental spills and leaks	Local	Temporary	Minor
Disturbance	Snow plowing/drifting Indirect effects of gravel fill (fugitive dust, impoundments) Accidental spills and leaks	Local	Temporary	Minor

Impoundment of surface water adjacent to gravel fill is an indirect effect that may convert terrestrial habitats (dry to wet tundra) to aquatic or open water habitats. The effects of impoundments to vegetation and wetlands can be temporary, or they can persist throughout summer. Depending on the duration of seasonal impoundments, effects on vegetation range from minor to moderate. Habitat conversion because of impoundments may potentially affect relatively large areas. Pollard et al. (1989), using aerial photographs of Prudhoe Bay, identified a greater area of surface water impoundment adjacent to gravel than gravel fill itself. The indirect effects of impoundments on vegetation and wetlands may lead to increased primary and secondary productivity, which in turn may provide more favorable habitat for certain species of waterfowl (Kertell and Howard 1992). Adversely, deeply flooded impoundments may flood elevated microsites used for bird nesting. Surface water impoundment may be mitigated through proper culvert sizing and siting; proper culvert maintenance, such as clearing before spring break-up; and use of bridges in lieu of culverts, where appropriate.

An additional indirect effect of gravel placement is thermokarst, when ground ice melts and the surface caves or settles. Thermokarst is a natural process that can be exacerbated by placement of gravel fill, dust fallout, or surface water impoundment. Thermokarst has the potential to create long-lasting hydrological and ecological changes, some of which may be considered beneficial: enhanced primary productivity, decomposition, nutrient release, and nutrient concentrations in plant tissue (Challinor and Gersper 1975; Chapin and Shaver 1981; Ebersole and Webber 1983; Emers et al. 1995; Truett and Kertell 1992).

Dust will be generated from the grading and compaction of gravel roads, pads, and airstrip as well as with general heavy equipment and light traffic use of gravel roads and pads. The effects of fugitive dust, dust which lands on tundra downwind from gravel roads and pads, are most pronounced within 35 feet (11 meters) of the source (Walker and Everett 1987). The zone of heavy dust fallout around the Project facilities is approximately 130 acres. The magnitude of dust effects depends on traffic speed and intensity, distance from the source, and substrate acidity (Everett 1980; Walker and Everett 1987; Auerbach et al. 1997). The indirect effects of gravel fill associated with dust fallout within this zone may include (Everett 1980; Spatt and Miller 1981; Werbe 1980; Klinger et al. 1983; Walker et al. 1985; Walker and Everett 1987; Auerbach et al. 1997):

- Physical burial of vegetation (direct effect),
- Advanced snowmelt (up to two weeks) because of decreased albedo (the fraction of the incident sunlight that is reflected),
- Increased depth of seasonal thaw (to 20 inches in ice-rich areas),
- Thermokarst,
- Early green-up of plants,
- Increased soil pH (effects associated with increased alkalinity of the tundra environment are less germane to the Project than they are to other areas on the North Slope. Similar to Prudhoe Bay, the Project is located in an area of loess deposition with more alkaline soils than many North Slope regions [Walker and Everett 1991]),

- Reduced photosynthetic capacity of plants,
- Lower nutrient levels in vegetation,
- Decreases in acidophilus mosses (particularly *Sphagnum*) and some lichens (*Cladina* and *Peltigera*) concomitant with an increase in other mosses,
- Decreases in some prostrate shrubs (*Dryas* and *Ledum*), and
- Barren patches of ground.

These indirect effects will cause both mortality/loss and disturbance. Applying dust control measures such as watering the roads during summer, chip sealing gravel surfaces, or applying a commercial dust control product, in concert with enforcing vehicular speed limits at all times, will help mitigate potential effects from dust fallout.

Ice Roads and Pads

For the Project, land-based ice roads will be used to support gravel mining; pipeline construction; and construction of gravel roads, pads, and airstrip. A fuel storage area will be constructed, within containment, on an ice pad and ice pads will be used for overburden stockpiles during gravel mine operations.

The direct effects of ice roads are greater in dry, shrub-dominated habitats than in wet, graminoid-dominated habitats (Jorgensen et al. 2003; Yokel et al. 2003). Dry, shrub-dominated habitats most sensitive to damage from ice roads include ridges, banks, dunes, tussocks, and high-centered polygons. These habitats are most common in the following vegetation types: moist sedge, dwarf shrub tundra (Va); moist tussock sedge, dwarf shrub tundra (Vb); dry dwarf shrub, crustose lichen tundra (Vc); dry dwarf shrub, fruticose lichen tundra (Vd); dry barren/dwarf shrub, forb grass complex (IXb); and dry barren/dwarf shrub, grass complex (IXf). Collectively, the vegetation types containing these potentially sensitive habitats encompass approximately 160 acres, or 34 percent, of the anticipated ice road footprint (Table 4-18).

A direct effect of ice roads and pads is mortality of vascular and non-vascular plants (Adam and Hernandez 1977; Johnson and Collins 1980; Walker et al. 1987). Crushed tussocks and willows, as well as bryophyte mortality, have the potential implication of long-term changes in species composition for areas beneath ice roads and pads. Vegetative communities generally recover from limited mortality within a few years.

The direct and indirect effects of ice roads on tundra vegetation are measurable and typically limited in extent and duration. Likely disturbance effects to vegetation and wetlands include soil and vegetation compaction, delayed snowmelt the spring after use, localized soil disturbance, and damage to vascular and nonvascular plants (Adam and Hernandez 1977; Johnson and Collins 1980; Walker et al. 1987).

The magnitude of effects varies with the ice content of underlying soils (Adam and Hernandez 1977), vegetative composition (Walker et al. 1987; Jorgensen et al. 2003; Yokel et al. 2003), and duration of use (Adam and Hernandez 1977). Plant communities generally recover from limited damage within a few years, and vegetation and wetlands are affected less by ice roads than they would be by construction of gravel roads.

Water Removal

Withdrawal of water from lakes for construction of ice roads and consumptive use has potential to alter wetland community structure by temporarily changing the hydrologic regime. Lakes identified for potential use in ice road construction in the Preliminary Construction Plan are Pit C-1 and the lake south of the pit. The effects of water removal will be mitigated by minimizing the amount of water necessary for ice roads, and limits on amounts of water withdrawn from permitted lakes.

Pipelines

Table 4-18 describes which habitats and vegetation types may be affected by pipeline alignment. The dominant vegetation types within the pipeline alignment are moist sedge, dwarf shrub tundra/wet sedge tundra complex (IVa) and moist sedge, dwarf shrub tundra (Va), each encompassing more than 50 percent of pipeline alignment (Table 4-18). Ice roads constructed to install the pipeline will have temporary effects on approximately 245 acres of these vegetation types out of a total of 477 acres. VSMs will be installed during pipeline construction, resulting in a long-term loss of vegetation and wetlands. VSM installation is anticipated to be at approximately 60-foot spacing along pipelines, with a 24-inch hole per VSM. While the exact locations of VSMs have not been determined the total area filled by VSMs is less than one acre.

Gravel Mine Development

Gravel mine development (including gravel storage pad) would result in a loss of approximately 70 acres of tundra to the gravel mine and associated gravel storage pad (Table 4-17). The vegetation types that would be most affected by the gravel mine are wet sedge/moist sedge, dwarf shrub tundra complex (IIId) and moist sedge, dwarf shrub tundra (Va); together, these two types comprise approximately 85 percent of the gravel mine footprint (Table 4-17).

Spills and Leaks

Contaminant spills will be a consideration and concern during all Project phases. The most common accidental spills in the North Slope oil fields are fuels and vehicle/machinery lubricants. For the most common spills in the oil field, predictable alterations in the plant community include mortality of woody plants and herbaceous flowering plants. The most common spills on the North Slope are relatively small and can be cleaned up with minimal effect on vegetation; reasonably productive plant cover can be achieved within several years, with some rehabilitation effort. Personnel at the Project site will be properly trained in spill and clean-up procedures. Major spills are addressed in Section 4.4; for all other spills, effects to vegetation can range from none to moderate, depending on the toxicity of the product spilled and the measures taken to clean it up.

4.2.2.3 Operations

Routine activities such as driving or operating equipment on gravel roads and pads, plowing roads and pads during the winter, and fueling and operating equipment have the potential to directly and indirectly affect vegetation and wetlands in the Project area, causing both mortality and disturbance.

The indirect effects of using gravel roads and pads, creation of snow dumps and snow drifts, and accidental spills and leaks are anticipated to disturb vegetation and wetlands during Project operations. Disturbance associated with each component is anticipated to be local and short-term, and the overall effects of mortality and disturbance to vegetation and wetlands in the operations phase of the Project is anticipated to be minor. This is because of the local nature of the effects, the prevalence of wetlands in the Project area, the function and value of affected wetlands, and the temporary nature of the disturbance effects. Direct and indirect effects of activities associated with operations are described in this section and outlined in Table 4-19.

Dust Generation

A direct effect resulting from the operations phase of the Project is the creation of fugitive dust adjacent to roads and pads. As discussed in subsection dust generation may cause mortality and disturbance to vegetation in the vicinity of the road or pad.

Snow Dumps and Snow Drifts

Winter snow accumulation on pads, roads, and the airstrip will be plowed to the side. In some cases, the snow will be pushed off the gravel surface and will accumulate on the frozen tundra. Drifted snow may also accumulate adjacent to the gravel areas with higher relief than the surrounding tundra. Accumulated snow may result in delayed snowmelt and soil compaction. Effects on vegetation may be long-term because of the chronically reduced growing season, soil compaction, altered moisture regime, and gravel fallout. According to the Western Regional Climate Center (WRCC 2009) Database (http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?ak7780), average snowfall is 33 inches per year. Because large accumulations of snow are not anticipated for the region, the areas potentially affected by snow dumps and snow drifts associated with the 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, may minimize any changes to vegetation.

Spills and Leaks

Direct and indirect effects from spills and leaks are discussed in Section 4.2.2.2 Construction.

4.2.3 Fish

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.2.3. Consequences are presented for drilling, construction, and operations.

4.2.3.1 Marine Fish and Nearshore Habitats

Marine, freshwater, and diadromous fish species and their habitats in the Project area, are discussed in Section 3.2.3. Potential effects of the Project on these biological resources are summarized in Table 4-20. Because the likelihood and magnitude of Project effects are different for freshwater/diadromous fish than for marine species, these two groups are discussed separately with marine fish covered in this section, and freshwater/diadromous species covered in the following section.

Possible Project effects on marine fish and nearshore habitats include:

- Spills of drilling-related materials or petroleum products that may reach the marine environment;
- Effects of ice roads on marine fish and invertebrates (i.e., entrainment), and on algal productivity; and
- Effects of barge and small boat traffic and associated infrastructure on nearshore habitat and fish.

These effects are discussed relative to drilling, construction, and operations below.

Drilling

Drilling-related materials (cuttings, drilling fluids, unrefined hydrocarbon liquids), well production products (including produced waters, unrefined crude oil, or petroleum condensates), and refined oil products such as diesel (for fueling support equipment) could be introduced to the marine environment through runoff from land-based spills. Although the probability of such introductions is low and will be minimized by design measures and standard work practices, any such introductions could result in effects to the marine nearshore in the form of habitat degradation or loss through direct toxicity, reductions in water quality, or changes in the types and number of plants and animals present through mortality or avoidance.

Drilling-related spills, though likely, are expected to be small, contained on the drilling pads, and easily cleaned up. In addition, drilling will primarily be done mostly under winter conditions, so even if such spills reached surrounding tundra habitats, there would be no surface water to carry them to marine habitats, and they could be cleaned up before ice break-up would make such transport possible. Recovery and reuse of drilling fluids during drilling operations, and the planned disposal of cuttings and spent drilling fluid through injection of them into a disposal well, will reduce the amount of stockpiled waste material that would need to be contained. By extension, recycling and subterranean disposal of drilling fluids further reduce the limited potential that drilling-related spills or runoff could affect marine resources. For all these reasons, no affect of drilling-related spills on marine fish and environments is expected. For more information about potential spills, see Section 4.4.

TABLE 4-20: SUMMARY OF THE LIKELY EFFECTS* ON MARINE AND FRESHWATER FISH

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope/Magnitude[2]	Duration[3]	Context[4]	
Drilling					
Habitat Loss and Alteration Gravel Placement; Ice Roads/Pads	Low (few onshore facilities during drilling)	Local	Temporary (but continues through construction and operation)	Very minor effects on diadromous fish habitat/distribution where pads alter freshwater habitats and on marine fish where ice roads preclude use of marine habitats	Minor
Disturbance Noise and Traffic	Low	Local	Temporary (but continues through construction and operation)	Very minor effects on diadromous fish where pads or roads are adjacent to freshwater habitats	None to minor
Lethal/Sub-lethal Effects Spills, Leaks, and Contamination	High	Local	Long-term	Contamination reaching fish streams would affect most species	Minor to moderate (level of effect would vary depending on the nature/location of the spill)
Water Removal	Low	Local	Temporary	Minor effects on diadromous and resident fish habitat/distribution where dewatering alters freshwater habitats	Minor
Construction					
Habitat Loss and Alteration from Ice/Gravel Roads	Low	Local	Ice roads – temporary; Gravel roads – permanent	Minor effects on diadromous fish habitat/distribution where roads alter freshwater flows/habitats; on marine fish where ice roads preclude use of marine habitats	Minor
Water Removal/Reservoir (Gravel Lne) Filling	High	Local	Temporary	Minor to major effects on diadromous and resident fish habitat/distribution where dewatering alters overwintering habitats; filling reservoirs can cause flow reductions in spring	Minor to moderate depending on degree of loss of winter/spring habitat; populations at risk generally small
Dust Fallout/Road	Low	Local	Temporary/long	Siltation affects	Minor

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope/Magnitude[2]	Duration[3]	Context[4]	
Runoff			Term	Stream/lake productivity, fish prey location	
Spills, Leaks, And Contamination	High	Local for terrestrial spills (large spills into the marine environment could have regional effects)	Long-term/permanent effects on habitats	Affects most freshwater or marine species	Minor to moderate (level of effects would vary depending on the nature of the spill)
Disturbance Effects Noise Effects (Blasting In Gravel Pits; Pile Driving)	High (high levels during blasting if near streams, and during marine pile driving but would be conducted in winter when no marine life present)	Local	Temporary	Blasting affects most fish species, primary concern for species wintering near gravel pits	None to minor
Vehicular Traffic Disturbance	Low	Local	Temporary (but continues through operation)	Very minor effects on diadromous fish where pads or roads are adjacent to freshwater habitats	None to minor
Marine Vessels And Barge Landing Site Disturbance	Low to medium (varies based on vessel type)	Local	Temporary (summer season)	Grounded barge affects migration patterns; prop wash/noise affects many species in nearshore waters	Minor
Mortality Effects Spills, Leaks, And Contamination	High	Local (large spills into the marine environment could have regional effects)	Long-term	Affects most species	Minor to moderate (level of effects would vary depending on the nature of the spill)
Operation					
Habitat Loss And Alteration From Ice/Gravel Roads.	Low	Local	Ice roads – temporary; Gravel roads – permanent	Minor effects on diadromous fish habitat/distribution where roads alter freshwater flows/habitats; on marine fish where ice roads preclude use of marine habitats	Minor
Water Removal/Reservoir (Gravel Mine) Filling	High	Local	Temporary	Minor to major effects on diadromous and resident fish habitat/distribution where dewatering alters overwintering habitats; filling reservoirs can cause flow reductions in spring	Minor to moderate depending on degree of loss of winter/spring habitat; populations at risk generally small

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope/Magnitude[2]	Duration[3]	Context[4]	
Dust Fallout/Road Runoff	Low	Local	Temporary/Long-term	Siltation affects stream/lake productivity, fish prey location	Minor
Spills, Leaks, And Contamination	High	Local for terrestrial spills (large spills into the marine environment could have regional effects)	Long-term/permanent effects on habitats	Affects most freshwater or marine species	Minor to moderate (level of effects would vary depending on the nature of the spill)
Disturbance Effects Noise Effects (Blasting In Gravel Pits)	high (high levels during blasting if near streams but would be conducted in winter)	Local	Temporary	Blasting affects most fish species, primary concern for species wintering near gravel pits	None to minor
Vehicular Traffic Disturbance	low	Local	Temporary (but continues through operation)	Very minor effects on diadromous fish where pads or roads are adjacent to freshwater habitats	None to minor
Marine Vessels & Barge Landing Site Disturbance	low to medium (varies based on vessel type)	Local	Temporary (summer season)	Grounded barge affects migration patterns; prop wash/noise affects many species in nearshore waters	Minor
Mortality Effects Spills, Leaks, And Contamination	High	Local (large spills into the marine environment could have regional effects)	Long-term	Affects most species	Minor to moderate (level of effects would vary depending on the nature of the spill)

Notes:
1 Intensity (severity) = low, medium, high
2 Scope / Magnitude (geographic) = local, regional (across Alaska Beaufort coastal area)
3 Duration = temporary, long-term, permanent
4 Context = common, important (diadromous species), unique (none)
5 Overall = none, minor, moderate, major. The effects being assessed for each project activity/component are: 1) long-term habitat loss from gravel extraction and gravel placement for the construction of three gravel pads, the airstrip, barge berth, boat ramp, and the interconnecting road system; 2) temporary habitat loss from water withdrawals for ice road construction and general use and from filling of reservoirs during spring runoff; 3) changes in productivity or the use of habitats altered by siltation from upland and marine construction and runoff from roads, pads, and runway; 4) behavioral disturbance of fish by equipment operation and human activity (pile driving, barge movements, large vehicle traffic near streams 5) injury and mortality of aquatic species and long-term habitat loss due to accidental spills.
* This table present anticipated effects of the Project and does not include major spills or well blowouts.

Construction

Construction activities could affect marine fish and habitats through barge landings and construction of the proposed ice road connecting the Project site with the existing permanent road system at Endicott. The annual sea ice road will be approximately 60 miles long and approximately 100 feet wide. It will be constructed each year for the 3-year construction period. Sea water for the road will be withdrawn from locations along the road alignment by drilling through sea ice and then pumping the salt water across the surface of the ice. Freshwater from inland sources will be used to cap the sea ice road. This technique is used for grounding sea ice and increasing sea ice thickness to provide load-bearing capacity for vehicle travel. Using figures from the NSB Comprehensive Plan (NSB 2005) an estimate of the amount of water needed for this road can be derived as between 2.5–3.75 million gallons of water per mile, or approximately 156 million gallons of water per year. This water will be drawn at a time of year when bottom-fast sea ice is present throughout the nearshore area. This could result in entrainment of marine fish during the pumping of sea water. Arctic flounder, four-horned sculpin, and Arctic cod (see Section 3.2.3 for descriptions and life histories), would still be vulnerable to entrainment, because the saltwater pumping rates may exceed 1,000 gallons/minute and fish may be lethargic because of decreased metabolism as a result of near-freezing temperatures. Though loss of these fish is not expected to have any effects at the population level, local minor to moderate effects to fish that use the areas where saltwater is pumped may occur.

During the open water season, barge and small boat traffic will be used as required between the dockheads at Prudhoe Bay (West Dock), Endicott, and Point Thomson. To safely ground the large ocean barges sufficiently close to the bulkhead, the seafloor will require some dredging and screeding (leveling), at least before the first shipping season. Dredging/screeding will generally be limited to the area needed for landing (grounding) the first barge. Up to 1,500 cy of excess material may potentially be removed to provide the required seabed profile.

Once the first barge is tied up and offloaded, a second barge will be brought in and tied end to end to the first. The second barge may also be partially grounded. Once the second barge is unloaded (across the first), it will remain in place. As subsequent barges are brought in they will be tied to the end of the second, and offloaded across the first two barges. It is anticipated that these subsequent large ocean barges will be in place at the Project site for approximately 14 days, providing adequate time to dock and offload cargo. At the end of the transport season, all the barges will leave the site. This method of barge access will be employed for up to three construction seasons (2012–2014).

The possible effects of the barge offloading facility include:

- Functional loss of nearshore marine habitat from the installation of the bulkheads, the screeding and shallow dredging from -1 to -6 MLLW, and in the dolphin and barge footprints;
- Disturbance of nearshore habitat from propwash of guiding vessels;
- Temporary shading and disturbance of the marine nearshore under the grounded barges;

- Noise effects from pile-driving during construction and vessel traffic during operation;
- Temporary barrier effects on passage by marine and diadromous fish; and
- If dredge material is disposed along the nearshore, a possible increase in local turbidity as the newly deposited seabed material resorts from wave activity.

This barge infrastructure option has a footprint of approximately 2.6 acres (nearly 1.4 acres of structural footprint from bulkheads and grounded barges and 1.2 acres of dredging/screeding). Despite this, negative effects to the marine nearshore would be minor. The habitat lost from the grounded shallow section and associated guide dolphins would be at an elevation annually affected by bottom-fast ice and represents a very small proportion of the marine nearshore habitat associated with the Project. Both barges may create a solid or perceived (through shading) barrier to fish passage in the very shallowest portion of the marine nearshore. This would likely have minor adverse effects on fish use of the marine nearshore, as migratory fish use a much broader area of the shallow water nearshore than would be occupied by the barges. Fechelm et al. (2009), routinely placed fyke net sampling locations further offshore than the reach of this proposed option and regularly captured transient and migratory fish species with similar catches per unit effort to those placed at the shoreline. Benthic productivity from deeper areas not subject to bottom-fast ice is considered low (Dunton 1984) and naturally limited because of intermediate levels of disturbance from large ice pieces during initial ice break-up each year. Thus, both shading and disturbance from propwash from guiding vessels would be likely to have minor or no measurable effects on benthic productivity and habitat value.

North Slope-based coastal barges deployed for marine transport will make landings at the low bulkhead. These shallow-draft vessels will make landfall on a gravel beach at tidal heights that are directly affected by bottom-fast ice annually. Because of this, and given the limited time such barges will remain in place, the operation and use of these types of barges at the low bulkhead will likely have no measureable effect on fish and invertebrates in the marine nearshore.

Propwash disturbance from the guiding vessels could result in sediment suspension and turbidity, but any effects would likely be localized and short-lived because of the alongshore currents associated with the Project area (Niedoroda and Colonell 1990) and therefore would be expected to have no negative effect on water column productivity or fish migration patterns. The effects of pile-driving (e.g., waterborne noise) on fish would be reduced or eliminated by installing piles during the bottom-fast ice period. This would eliminate the need for barge-mounted driving machinery (eliminating propwash and grounding effects) and precludes the presence of sensitive marine species (diadromous fish) in the area during pile-driving.

In addition to the grounded barge, an Emergency Response Boat Launch will be constructed along the southeastern shoreline of the Central Pad. The concrete launch ramp will 150 feet long by 16 feet wide and extend to approximately 3.5 feet below MLLW. Alongside this ramp will be an approach trestle, gangway, and floats that measure a total of 195 feet long by 8 feet wide. The footprint of the ramp would constitute a minor loss of nearshore marine benthos in an area routinely disturbed by bottom-fast ice annually, which would limit any effects. Although these structures could create another solid or perceived barrier (through shading) to fish passage in the marine nearshore, the much smaller footprint will likely prevent most effects.

Overall, the effects on marine nearshore fish from the Boat Launch should be minor or none because of the location, size, and infrequent and localized nature of any vessel-related disturbance.

It is unlikely that the proposed barge traffic (shallow or deep) or early response vessel use will have any measurable effect on the marine nearshore beyond that already resulting from annual ice cover. Most fish in the landing area, if present, are likely to move away in response to the noise and disturbance associated with barge arrivals. Thus, effects to fish from boat and barge landings are also expected to be minor.

Operation

A major pipeline spill that reached the Beaufort Sea is the worst potential effect to marine nearshore resources associated with operation of the proposed facilities. Lesser effects could result from sea ice roads that are to be constructed every year and use of barges during open water periods of the year. These effects are discussed under the construction section above. Similar effects would occur if ice roads are constructed and barge infrastructure remains in use during the longer-term operations at the Project site.

A large spill of petroleum hydrocarbons (diesel, crude oil, or condensates) could contaminate nearshore habitats, leading to mortality or impairment of a large number of marine species. Because the remoteness of the Project site could hinder a marine clean-up effort, and because of the persistent summer winds of the Beaufort Sea, a petroleum spill that exceeded the on-site response capacity could rapidly be transported along an extensive area of coastline.

A large spill is a remote possibility. The extensive use of the North Slope for petroleum product development has led to decades of experience in preventing or effectively mitigating for spill events, both major and minor (Borough of Land Management [BLM] 2008). For example, all oil, gas, or condensate pipelines will have automated systems to quickly detect leaks and shut down liquid transport to reduce the size of any spills. In addition, regular visual inspections of pipelines for leaks, damage, or corrosion will occur, allowing for repairs or maintenance that will reduce the likelihood of a larger spill. Staff trained in spill response will be on site at all times and can rapidly mobilize and implement clean-up activities as needed using the established procedures of the Spill Prevention and Response Plan.

In addition to BMPs used to reduce, minimize, and respond to spills, there are several reasons to believe that introduction of petroleum hydrocarbons from this Project will have a low likelihood of negatively affecting the marine environment. The first is that there is little direct connection between the proposed pipelines and related facilities and the marine nearshore environment. Most of the petroleum collection and processing infrastructure is being built upon engineered foundations (gravels pads with insulating layers) with institutional controls in place to limit the escape of potentially harmful materials. Whether from pads or elevated pipelines, any petroleum products that might be spilled onto the tundra would still require surface runoff during precipitation or small streams for transport to the marine nearshore. This means the pathways for transport of a spill are limited, which should both delay entry to marine waters and enhance the ability of clean-up crews to intercept spills before they reach those waters. In addition, given the climate, the majority of operations will occur during freezing conditions. This is important for two reasons:

- Any spill of liquid materials such as high-molecular-weight hydrocarbons would probably remain localized, because they are likely to freeze or at least become viscous. This would decrease the area affected and increase effective response time, thereby reducing the chance that these materials could reach the marine nearshore environment.
- The major pathway by which spilled materials could reach the marine nearshore is through freshwater transport (runoff, streams, melt channels, or installed culverts). Most of these would not be viable pathways during freezing conditions when little or no free water is present. Thus, potential inputs to the marine environment would be negligible during such times.

Given the mitigating measures included in the design and operating practices at the facility, the probability of a large spill is low, and the effects on marine fish and habitats of petroleum spills during operations of the Project should be minor or absent. However, if a large spill were to reach marine waters, it could have a major negative effect on marine fish and habitats.

Essential Fish Habitat

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act set forth the Essential Fish Habitat (EFH) provision to identify and protect important habitats of federally managed marine and anadromous fish species. Federal agencies, such as the U.S. Army Corps of Engineers (USACE), which fund, permit, or undertake activities that may adversely affect EFH, are required to consult with National Oceanic and Atmospheric Administration (NOAA) Fisheries Service (NMFS) regarding the potential effects of their actions on EFH, and respond in writing to NOAA Fisheries' recommendations.

Essential fish habitat is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NMFS 1999).

In 2005, a Final Environmental Impact Statement (EIS) for EFH in Alaska was issued by the NMFS and the North Pacific Fishery Management Council (NPFMC 2005). This included a decision on how EFH should be identified and a current description of these habitats by species based on the preferred alternative. The only EFH designated along the North Slope is for salmon. This includes five species of Pacific salmon: chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), pink (*O. gorbuscha*), sockeye (*O. nerka*), and chum (*O. keta*). Federal agencies are required to consult with the NMFS on activities, including non-oil and gas activities and oil and gas leasing and development that may adversely affect the EFH. This consultation should be consolidated with environmental review required by other statutes, such as the NEPA (50 CFR 600.920(e)).

Generally, there is little evidence of viable, self-sustaining salmon populations in the Beaufort Sea and the northern (north of 70 degrees (°) N latitude) Chukchi Sea. Present salmon "populations" have a very difficult time establishing and persisting in the Arctic, most likely because of the marginal habitats (Craig 1989a; Fechhelm and Griffiths 2001). Conclusions based on a survey of available information describing salmon stocks in the Beaufort Sea (Fechhelm and Griffiths 2001) indicate only a few isolated spawning stocks of chum and pink salmon that might occur in the region, primarily the Sagavanirktok and Colville rivers. Small runs of pink and chum salmon have been noted in the Colville River (Bendock 1979; McElderry and Craig 1981) and in recent years these species have been taken in the Colville and Itkillik rivers as part of the fall subsistence fishery (Burns 1990). However, catches in scientific sampling and in the subsistence fishery are extremely low (Craig 1989a; Moulton 1994, 1995). Chinook, coho, and sockeye salmon are even more rare than pink and chum salmon in the region. The salmon populations in and adjacent to the Project can therefore be considered marginal.

More details on habitat in the Project area are discussed in Chapter 3, Affected Environment.

Ecologically, EFH within the Beaufort Sea and northern Chukchi Sea is most likely to be utilized by salmon from other areas rather than as a result of localized reproduction. The scarcity of salmon documented in the Beaufort Sea indicates that regardless of source, EFH in the Project area receives little use by these species. However, water temperature increases in the Arctic could lead to a substantial increase in salmon distribution, numbers and habitat use. There is some evidence, including published first records of salmon in the Canadian Beaufort Sea over the last decade, suggesting that increased utilization by salmon may already be occurring in the Beaufort (Babaluk et al. 2000).

Based on best management practices implemented to eliminate or reduce effects from the Project, the mitigations suggested in Chapter 5, and the low numbers of salmon utilizing freshwater and marine habitats, this Project is not expected to affect salmon or their habitat and is assigned the EFH determination: ***May affect, not likely to adversely affect***.

4.2.3.2 Freshwater and Diadromous Fish and their Habitats

The Project includes a number of activities and structures that could affect freshwater and diadromous fish, including:

- Water withdrawal from area streams, ponds, and lakes;
- Construction and maintenance of roads, pads, and pipelines;
- Gravel mining, transport, and placement;
- Use and reprocessing of drilling muds; and
- Refueling and maintenance of equipment, and vehicles.

Potential effects derive from habitat loss, adverse habitat changes, degradation of water quality, and direct toxicity or mortality to fish and the aquatic prey species they depend on. The extensive history of oil/gas development on the North Slope has resulted in development of a number of effective mitigations to reduce effects on fish and aquatic habitats (BLM 2008). The Project incorporates many of these mitigation strategies, with the result that, in the absence of a major spill, effects are expected to be minor and localized.

Drilling

Drilling operations will use extensive quantities of drilling fluids, which in turn will require large amounts of fresh water from local sources. Water use from local sources will also be needed to support the workforce engaged in drilling operations. Drilling will produce large amounts of used drilling fluids and cuttings that will have to be stored until a disposal well is operational. In the event of a well blowout, large amounts of drilling fluids and produced gas/petroleum condensate/water could be spilled on the drill pad. Potentially, some of these materials could flow from the pad onto adjacent tundra, streams, or ponds. The equipment and vehicles used to support drilling will require substantial amounts of refined oil products (e.g., diesel, lubricating oils). Gravel mining and fill of wetland and/or aquatic habitats to expand drilling pads and associated roads also will occur.

Thus, drilling has two major types of potential effects on fish: introduction of materials into local streams and lakes, and removal of fresh water from these habitats. Direct introduction of drilling fluids, refined oil products, and produced gas/oil/water to area waters could occur if a spill were large enough to escape the drilling pad. Similarly, stored drilling fluids and cuttings could be subject to runoff or leaching of chemicals into area streams and ponds if reserve pit liners were improperly installed or if they failed. Whether through direct spills, or via runoff, introduction of these materials into area waters has the potential to affect freshwater and diadromous fish through direct toxicity, toxic effects on prey species, and reductions in water quality conditions such as turbidity.

A number of measures are included in the Project to reduce or eliminate these potential negative effects on fish. Because all drilling will be done from gravel pads, the potential for introduction of materials to streams and lakes from spills or runoff will be greatly reduced. In practice, although small spills on drilling pads are common, they are easily contained and cleaned up (BLM 2008). Drilling will also be done predominantly during freezing conditions, so that spilled material that escapes from the drilling pad could be cleaned up before ice break-up, thereby preventing its entry to streams and lakes. The Project has a Spill Prevention and Response Plan and will have staff trained in spill response, plus the materials necessary to clean up any spills at drilling locations on site during all drilling. Reuse of drilling fluids, and disposal of fluids and cuttings in the disposal well, once operational, will substantially reduce the amount of stored materials that could be subject to runoff or leaching. Given these mitigation measures, drilling-related spills or runoff are expected to have minor or no effects on freshwater fish or habitats

Water demand associated with drilling could be substantial. BLM (2008) estimates that 63,000 gallons/day or up to 850,000 gallons of water total could be needed to drill a well on the North Slope. In addition, the combined drilling/construction workforce may exceed 400 people, each using 50–75 gallons/day, for an additional demand of 20,000–30,000 gallons of water/day. As detailed in Section 3.1.3, most streams and lakes in the Project area freeze solid during the winter, so this water demand will initially have to be met from limited amounts of free water that can also be important as overwintering areas for fish. The result could be to reduce habitat or water quality conditions needed by fish, which may result in crowding, stress, or mortality.

Effects on fish and habitats from fresh water use will be mitigated in the early years of the Project by adhering to ADF&G rules regarding water usage. There rules require that no more than 15 percent of the free water of a stream or lake can be withdrawn if fish are known or suspected to be present, to assure sufficient water quality and habitat space for fish survival until ice break-up. Ultimately, most of the fresh water needs of the Project will likely be derived from water stored in the basin excavated through gravel mining. If planned fish-excluding devices are effective, this large body of water will not serve as habitat, and therefore water withdrawals will have no effect on fish. If fish do colonize the flooded mine, then ADF&G pumping limits to protect fish would likely apply. However, the diversion of surface waters to refill this reservoir each year during high streamflows during ice break-up will reduce downstream flows; this could have a localized and short-term effect on fish and fish habitat. Overall, however, effects on freshwater and diadromous fish are expected to be minor, given these mitigations

Construction

To provide gravel for construction activities, a gravel mine will be established as part of the Project. Excavation will occur over an approximately 60-acre area that currently contains a number of small tundra lakes, and the resulting basin will be flooded with water from surface streams to create a reservoir. Gravel storage, roads, and other facilities associated with gravel mining will cover approximately another 102 acres, resulting in the fill of additional surface waters. Within the larger Project area, a number of new gravel roads with stream crossings will be constructed, and existing roads and drilling pads will be expanded. A number of small tundra lakes will be filled through these construction activities. A gravel airstrip approximately 5,600 feet in length will also be prepared, although as currently sited it will result in the filling of only three to four small ponds. Land-based ice roads will be created each winter to support construction of permanent roads, bridges, elevated pipelines, and the airstrip. Ice roads will be limited to the immediate Project area, except for an extended road that will travel approximately 22 miles west to support construction of the export pipeline, and for spur roads to the seawater ice road that will be used to support construction work. These ice roads can persist longer than other ice and snow, potentially acting as barriers to overland and stream flow of waters at ice break-up. In addition, fresh water use for ice roads and for construction personnel could affect fish habitat and water quality.

Potential effects from gravel mining on freshwater and diadromous fish include excavation of existing tundra lake habitats, filling of others, and surface diversion of a large volume of water that could alter the amount and suitability of downstream aquatic habitats for fish. Both stickleback and Dolly Varden were present in the stream nearest the gravel mine (see Section 3.2.3) and so are assumed to be vulnerable to these effects. Given the large diversion, it is possible fish will gain entry to the new reservoir, in which case water withdrawals could directly affect fish in the future. Extensive heavy equipment used for both gravel mining and gravel transport has the potential to result in spills of refined petroleum products that could affect fish through direct toxicity or changes in prey availability. Stored gravel may also result in localized increases in turbidity through runoff and erosion of fine sediments from the stockpile.

Loss of existing tundra lake habitat associated with gravel mining will result in a small but permanent reduction in potential habitat for freshwater fish. Given the abundance of lake and stream habitats in the Project area, this loss is expected to have minor effects on fish. In addition, previous work indicates that these lakes may have ninespine stickleback, but probably do not contain species such as Dolly Varden that are more important to subsistence fisheries (Section 3.2.3). Diversion of surface waters into the gravel pit could reduce downstream habitat, however this filling will occur primarily during the short, high-flow period during ice break-up, when fresh water and fish habitat are both abundant, substantially reducing any negative effects. If fish are able to enter the flooded gravel mine, subsequent water withdrawals for construction activities could affect this new population of fish, but given an expected depth of more than 40 feet, and the use of ADF&G pumping limits, any reductions in habitat or water quality should be limited; extraction pumps will be equipped with screens to prevent direct entrainment, and therefore mortality of fish. Inputs of refined petroleum products or sediment to area waters is also expected to have minor effects, both because such discharges should be rare, and because when spills occur they most often can be cleaned up during frozen conditions before entry into streams and ponds.

New road construction will result in the loss of some fish habitat through filling. New roads, if not properly designed and maintained, may limit fish access to suitable spawning or feeding habitat (and overwintering habitat if present) if culverts and bridges become impassible because of ice/snow blockages, erosion, or other problems. Ponding of water behind roads may occur and can provide new fish habitat where such waters are connected to streams or ponds containing fish. Runoff and dust from newly constructed roads are likely to result in discharges of fine sediment to area waters, increasing turbidity levels and potentially causing in-stream sedimentation. Such runoff and dust would be expected both at ice break-up, and during re-grading and compaction of gravel roads during the first summer construction period. Runoff and dust could also include chemical constituents from road treatments or incidental discharges from vehicles.

As for the gravel mine, habitat losses from excavation and fill through tundra lakes are expected to have a minor effect on freshwater fish, given the local abundance of such habitats and the absence in many such waters of species used for subsistence purposes. New habitat from ponding behind road fill could have a small positive benefit by increasing the habitat and prey available to fish. Culverts and bridges for road stream crossings will be designed to allow for fish passage, and routine maintenance of these crossings will prevent ice/snow, erosion or other problems from limiting fish passage. Hence, effects on freshwater and diadromous fish from culverts and bridges should be minor. Discharge of sediment and chemicals from the road surface may occur, but given the high turbidities of area waters during parts of the ice-free season, and the very limited amounts of any chemical pollutants expected from road runoff, the effect on fish is again expected to be none to minor.

Construction of the airfield and expansion of the drilling pads would have potential effects on fish similar to those for road construction. Because the airfield and East and West pads are sited to avoid streams and most existing tundra lake, the level of expected effect of this construction on fish is expected to be minor. Pipelines will be constructed during winter using onshore ice roads, minimizing direct effects on fish and aquatic habitat. Placement of VSMs in or near small streams and defined drainages along the pipeline route may lead to localized erosion and increases in turbidity during the first ice break-up, but any effect on fish is expected to be minor and localized.

Ice road construction will require extensive use of fresh water. Although some of this fresh water need will be met with ice chips milled from the surface of frozen lakes, considerable quantities of free fresh water will also be needed. This could reduce the overwintering habitat for fish, leading to crowding, stress, or mortality through effects to DO and water chemistry. Given that they contain extensive quantities of frozen water, ice roads have greater thermal mass than many of the snow and ice fields they pass through. The result is that portions of ice roads can remain during the early stages of ice break-up, effectively forming a barrier to overland flow. This can disrupt natural water levels and drainage patterns, and can directly interfere with the movement of freshwater and diadromous fish.

Effects on fish from water extraction will be mitigated initially by adherence to ADF&G rules limiting withdrawals in streams and tundra lakes thought or known to contain fish. Ultimately, use of the flooded gravel mine as a water source will eliminate most adverse effects on fish, exceptions being fresh water extracted from other sources to construct the sea ice road, and the reduced downslope flows in local streams and ponds during ice break-up when the gravel quarry is refilled. With these mitigations in place, use of fresh water for ice roads is expected to have a minor effect on freshwater and diadromous fish. Similarly, changes to the salinity or chemistry of area waters when the ice roads melt is expected to have only minor or no effects on fish because of the rapid dilution of this meltwater by the high natural flows present at ice break-up. The potential for ice roads to affect fish by blocking overland flow or fish movement depends on siting and management. Routing the ice roads to avoid streams and tundra lakes reduces the likelihood of effects. In addition, yearly inspection and localized treatment (e.g., excavation through the ice road prism early in ice break-up) as needed to facilitate natural water movement would reduce the likelihood and magnitude of any such effects to minor levels.

Operations

With the exception of a major pipeline spill, operations separate from drilling and construction would have a limited potential to affect freshwater and diadromous fish. Freshwater extraction to support operations and meet employee needs will continue through the life of the Project. Graveled areas, including roads, pads, airstrip, and storage areas, will have vehicle traffic and will be maintained through grading, periodic additions of new gravel, clearance of bridges and culverts, and dust and snow abatement. These road-related activities could lead to sediment inputs to streams and tundra lakes. The potential for spills of both refined and unrefined petroleum products will continue both in the immediate Project area and along the entire route of the export pipeline. Sea ice roads may be constructed in some years to support operations. These roads would have a number of spur, fresh water ice roads traveling inland to water sources, to support inspections or repairs, or to facilitate reuse of gravel from exploration pads. Such spurs would require fresh water drawn from streams and lakes.

The effects of water withdrawal and use during operations would be similar to those for construction. However, given that the majority of the fresh water will come from the flooded gravel mine and that less fresh water will be needed because fewer miles of ice road will be constructed, the potential for effect is much lower. Overall, effects on fish are expected to be minor.

Both vehicle use on and maintenance activities of graveled structures would likely lead to some sediment inputs to area waters via runoff and dust. The magnitude of sediment input is expected to be much less than that associated with new road and pad construction. Watering (or similar application of dust control measures) of gravel surfaces, low traffic volumes during operations, and enforcement of vehicular speed limits will minimize dust effects on fish habitat from operations, traffic, and gravel maintenance activities. Thus, these potential water quality effects from dust and sediment inputs are anticipated to be minor and within naturally occurring turbidity variation in the fresh water environment (e.g., disturbance from ice, river runoff from ice break-up).

Minor spills of petroleum products on pads or roads are likely to be contained and cleaned up, thereby preventing most or all entry to local waters. Personnel will be trained in spill prevention and clean-up procedures. Spills that travel off operational areas will most likely accumulate on snow and ice, allowing clean-up of larger spills before entry of petroleum or drilling fluids into aquatic habitats. Spills from pipelines, by contrast, could put petroleum contamination directly on tundra habitats. To the extent these spills are small and occur in the winter, clean-up should be relatively effective in preventing most entry of petroleum hydrocarbons to area waters. However, pipeline spills during the ice-free period, or a large spill of any kind, could result in contamination of aquatic habitats and both direct (e.g., toxicity) and indirect (e.g., reduction in prey base) adverse effects on freshwater and diadromous fish. The magnitude of such effects would be dependent on the total quantity of petroleum hydrocarbons entering fresh water habitats, the nature of the material spilled, and the importance to fish of the specific habitats affected. In summary, small spills, particularly on pads, roads, and the airstrip are not likely to have effects on fish, but a large pipeline spill could lead to major effects including contamination of larger areas of aquatic habitat and lethal and sub-lethal adverse effects to fish. Section 4.4 discusses the risks and effects of oil and condensate spills in detail.

4.2.4 Birds

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in Section 3.2.4. Consequences are presented for drilling, construction, and operations. Effects on birds from the Project activities are expected to include the following:

- Loss of nesting and foraging habitats because of placement of gravel, and temporary losses of habitats from water withdrawal and delayed snowmelt (snow dumps and snow drifts);
- Positive and negative effects on use of habitats by shorebirds and waterfowl, depending on the species, because of impoundments (caused by gravel placement obstructing natural water drainages or flow);

- Changes in habitat quality and bird use of habitats altered by thermokarst or dust fallout from gravel roads/pads, and from oil or other contaminant spills;
- Temporary loss and/or displacement of birds from nesting habitats because of slow snowmelt (persistent snow dumps and snow drifts);
- Noise disturbance and avoidance of habitats near roads/pads because of vehicle traffic and operations equipment/facilities;
- Disturbance of birds by aircraft overflights and landing/take-offs at the Project airstrip;
- Increases in bird mortality from encounters with oil or other contaminant spills, flares, strikes by vehicles, and collisions with structures (trucks, aircraft, and infrastructure); and
- Increases in mortality of adults/young and egg loss at nests because of increased predator populations (human-animal interactions).

The following sections provide an assessment of potential effects and environmental consequences associated with the Project phases: drilling, construction, and operations. To reduce redundancy, the discussion will refer back to previous sections when effects and bird responses are similar among Project phases. The potential effects from the Project as far as area of long-term habitat loss for waterfowl and shorebirds, tundra-nesting species, and predatory birds are summarized in Table 4-17. Temporary effects on habitats loss as a result of ice roads are summarized in Table 4-20. This section does not include Threatened and Endangered Species. See Section 3.2.7 for the description of those listed species within the Project area, which include Yellow-billed Loon, Spectacled Eider, and Steller Eider.

4.2.4.1 Drilling

<u>Habitat Loss and Alteration</u>

Gravel Placement and Ice Roads/Pads

No gravel placement is planned for the initial Drilling phase, because drilling is being conducted from existing exploratory gravel pads with ice pad extensions, to be accessed by ice roads during winter. Drilling at West and East Pads would occur after the gravel pads are constructed. Gravel placement is expected to occur during the Construction phase and those effects on birds are discussed in Section 4.2.4.2 Construction. Both onshore and sea ice roads would be used during the winter Drilling phase activities. Onshore ice roads potentially would not melt until after most bird species begin nesting (late May–early June); thus, they could reduce the availability of nesting sites. In addition, compaction of standing dead vegetation under the ice road/pad would reduce plant cover needed by most birds for nesting sites. During the Drilling phase, small amounts of terrestrial habitat in the Point Thomson area would be affected by ice roads and pads. Additionally onshore ice roads would be located between the Sagavanirktok River and Point Thomson, where water source access roads or onshore portions of the main ice road occur. Studies in the Prudhoe Bay oil fields indicate that most shorebirds that exhibit fidelity to nest sites are displaced to adjacent unaffected habitats when a nesting area is lost. The effect of temporary losses of habitat from ice roads for the Project are anticipated to be minor, primarily because of the low magnitude of the effect, given that most displaced birds likely would nest in adjacent, unaffected habitats. Also, the effect would occur only in one–two summers during the Drilling phase, limiting the duration of the effect relative to the life of the Project.

Water Removal

Withdrawal of water from lakes to build ice roads potentially could alter wetland community structure by changing the hydrologic regime, and the resulting change in regime could affect bird use of waterbodies and their shorelines as nesting areas and/or as brood-rearing habitat. These changes could alter plant and invertebrate community structures, potentially decreasing the value of habitats used by waterbirds for cover or food. Many species of waterbirds tend to nest on small islands within tundra lakes (e.g., loons, grebes, Brant, Canada/Cackling Geese), and these birds and their nests could be affected if spring recharge is insufficient to compensate for water withdrawn the previous winter. Lakes to be used as water sources for ice road construction during the Drilling phase are identified in the Project Description. Use of water from these lakes would be permitted and permit stipulations likely would limit the amount of freshwater withdrawal. It is assumed that permitted water withdrawal limits are conservative and protective of affected waterbodies, which would reduce potential effects on bird habitats. The effects on birds from water removal are considered to be minor because of the limited geographic extent of this effect, and because regulatory requirements are protective, particularly of lakes with fish.

Snow Dumps and Snow Drifts

Similar to ice roads, the deposition of snow on tundra habitats from snow removal on the drilling pads and ice roads, or from drifts associated with the drilling pads, ice roads, and any snow fences, would result in persistent snow cover that may not melt soon enough for birds to use the covered habitats. Thus, snow dumps and drifts could cause temporary loss of nesting habitats for some birds, displacing nesting birds to adjacent unaffected habitats. The overall effect on birds is expected to be minor because of the limited areal coverage of these snow piles, the short duration of their occurrence, and the ability of birds to respond behaviorally to this temporary alteration in habitat availability.

Disturbance Effects

Noise and traffic associated with the Drilling phase that occur in winter and have no affect on birds, which are mostly absent from the area during winter. Some limited disturbance to resident birds, such as ptarmigan, may be possible during late winter when they begin to move out into the coastal plain. During the spring through fall, disturbance from drilling activity would be similar to that described for Construction phase (Section 4.2.4.2). Overall, the effect on birds of noise and traffic during the Drilling phase would be none to minor based on seasonality and limited exposure of most birds.

Mortality Effects

Bird mortality associated with the Drilling phase activities would be limited to possible collisions of birds with the drilling rig, camp infrastructure, and/or support vehicles under adverse weather conditions (i.e., when birds could not see and avoid these structures or any associated guy wires or towers). Because the rig is stationary, collision hazards would occur throughout the year, even when drilling activity has ceased. Therefore, collisions with the drilling rig could occur during both spring and fall migration periods, throughout the Drilling phase and into the Construction phase. Other potential sources of bird mortality associated with the Drilling phase could be from spills and leaks of oil or other contaminants on the gravel pad or onto the adjacent snow. It is unlikely that spills during winter Drilling phase activities would persist unnoticed long enough to affect resident birds and less likely that hazards would persist into spring migration during May–June. The greatest potential for mortality would be from a catastrophic well blowout during drilling that expelled large quantities of oil or other fluids onto the adjacent tundra and/or waterbodies, particularly during the late spring when birds are just arriving (Project restrictions on drilling in summer months would preclude major spills during that period). Such an event is unlikely, however, and clean-up plans and materials are in place for all drilling operations on the North Slope. An additional source of potential mortality would be the attraction of predators to the drilling rig and any subsequent increase in the predator population that continued into the summer months. The attraction of predators is minimized by the waste-handling practices currently in use on the North Slope. Overall, the effects of these Drilling phase activities that might affect bird mortality are considered to be minor, but could increase to major for any catastrophic spill event, particularly if just before spring migration when birds would begin arriving in the Project area.

4.2.4.2 Construction

Most Construction phase activities are planned primarily for winter, when most birds are absent from the Project area (only ptarmigan and Common Ravens are common winter residents on the ACP); therefore, these activities would be unlikely to cause disturbance effects for most species. Winter construction activities would occur for several years and would include ice road construction; gravel mining; gravel placement for roads, pads, and airstrip; and infield gathering and injection lines and export pipeline installation between the Central Pad and the Badami facility.

Summer construction activities could include many activities that may be disturbing to birds in the Project area, including grading, compacting, and reshaping road, pad, and airstrip; nearshore construction of the barge offloading system (bulkheads); periodic dredging prior to each annual sealift; and installing the modules (if that commences prior to fall migration). Most of these activities would take place from late May–mid-August, the period when many birds are present in the Project area.

Potential disturbance/displacement sources for birds during the Construction phase include aircraft traffic, vessel traffic in nearshore and offshore habitats, in-field vehicular traffic, facility construction noise, and waste handling.

Habitat Loss and Alteration

Gravel Mining and Placement and Ice Roads

During the Construction phase, gravel mining and storage are expected to occur in winter, with little or no effect on bird species in the Project region. Although some existing gravel from the exploratory pads would be reused, most gravel for roads and pads would come from a new gravel mine to be developed in the Project area (Figure 4-2). Approximately 138.2 acres (0.6 square kilometer) of habitats would be affected, including a gravel stockpile footprint (10.7 acres [0.04 square kilometers]), inorganic and organic overburden stockpile footprints (on ice pad for the winter season; 47.7 and 18.1 acres [0.19 and 0.07 square kilometers], respectively), a gravel mine/stream diversion road footprint (4.8 acres [0.02 square kilometers]), and the excavated surface area of 59.3 acres (0.2 square kilometers). The long-term long-term modification of approximately 70 acres (0.3 square kilometers) to aquatic habitat and temporary loss of 65.8 acres (0.27 square kilometers) of wetlands habitat to the gravel mine and associated storage and temporary stockpile areas is anticipated to have minor affects on birds at a population level because many birds are expected to be able to nest in nearby undisturbed habitats.

To minimize the Project footprint, the Central Pad (and bulkheads), East Pad, and C-1 Pad will incorporate existing gravel-covered areas (totaling 23.9 acres [0.10 square kilometers]; Table 4-17). Additional gravel placement for roads (93.4 acres [0.4 square kilometers]), pads (109.6 acres [0.44 square kilometers]), gravel mine development (73 acres [0.3 square kilometers]), the barge landing bulkheads at the Central Pad (0.8 acres [3,237 square meters], excluding 0.4 acres [1,619 square meters] of existing gravel pad), pipeline VSMs (2,500 square feet [232 square meters]), airstrip trenching (24,000 square feet [2,230 square meters]), and VSMs to support navigational aids at the airport (99 square feet [9.2 square meters]), increase the total long-term loss (terrestrial and fresh-water habitats only) to approximately 300 (1.12 square kilometers). The three most affected vegetation types (Table 4-17) would be wet sedge/moist sedge, dwarf shrub tundra complex (29.6 percent); moist sedge, dwarf shrub tundra (28.2 percent); and moist sedge, dwarf shrub/wet graminoid complex (15.3 percent). Existing gravel roads and pads is the fourth largest type, comprising 7 percent of the total Project footprint. Ten additional vegetation types comprise the remaining 19.9 percent of the Project footprint.

Important bird habitats (i.e., those supporting the highest diversity and density of bird species) in the Project area are primarily habitats containing wet tundra and those with aquatic components (ponds/lakes) 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 16.1 acres (0.07 square kilometers) (about 5.3 percent of the total acreage affected by gravel coverage and mine-site 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 permanent alteration of 1.1 acres (4,451 square meters) of salt marsh (about 0.4 percent of total gravel coverage).

Gravel placement and mining would result in the direct long-term loss of approximately 300 acres (1.12 square kilometers) of bird habitats and the creation of approximately 60 acres (0.24 square kilometers) of deep aquatic habitat at the gravel mine. Although most bird species in the region exhibit fidelity to nesting areas, studies in the Prudhoe Bay oil field suggested that most birds that lost nest sites to gravel placement were not prevented from nesting in subsequent years, but instead shifted their nesting efforts to adjacent, undisturbed habitats (Troy and Carpenter 1990; Troy 2000). In general, the amount of habitat expected to be lost as a result of the Project would be small relative to regional habitat availability, and the overall magnitude of the loss on birds would be low. In summary, the effects of long-term habitat loss for birds at a population level are anticipated to be minor because of the local scale of the effect. Although relatively little acreage would be lost and nesting habitats are not thought to be a limiting factor in the area, the loss of these habitats is measurable and is expected to affect some individuals on a local scale; these habitat losses would be unlikely to have a population-level effect for any species.

Onland ice roads would result in temporary effects to bird habitats by damage to the vegetation structure and late melt off the ice preventing use by tundra nesting birds. The primary onshore ice roads including the approximate 2.5-mile ice road from the Central Pad to the waters source (approximately 44 acres [0.17 square kilometers]), the approximate 3.0-mile ice road along the West Pad Road to support construction of three bridges (approximately 42 acres [0.17 square kilometers]), the ice roads to support pipeline construction from Central Pad to East Pad (approximately 70 acres [0.28 square kilometers]), Central Pad to West Pad (approximately 75 acres [0.3 square kilometers]), and from West Pad to Badami (242 acres [0.98 square kilometers) (Table 4-18).

TABLE 4-21: SUMMARY OF THE LIKELY EFFECTS* OF THE PROPOSED POINT THOMSON PROJECT ON BIRDS

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling					
Habitat Loss and Alteration Gravel Placement; Ice Roads/Pads; Water Removal; Snow Dumps, and Snow Drifts	Low (few onshore facilities during drilling)	Local	Temporary (but continues uninterrupted through construction and operation)	Affects all species, but of concern primarily for waterfowl, shorebirds, and passerines	Minor
Disturbance Noise and Traffic	Medium (moderate traffic levels during drilling, only during winter, primarily in nearshore)	Local	Temporary (but continues uninterrupted through construction and operation)	During winter affects only resident species (raven and ptarmigan), during summer affects all species	None to minor
Mortality Effects Spills, Leaks, and Contamination	High	Local	Long-term/permanent	Affects most species	Minor/moderate (level of effect would vary depending on the nature of the spill)
Increased Predation (resulting from Human/Animal Interaction)	Low	Local/regional	Temporary (but continues uninterrupted through construction and operation)	Beneficial effect in winter for ravens, but during summer adversely affects most bird species (beneficial effect for predatory/scavenging birds [gulls, ravens, and raptors])	Minor
Construction					
Habitat Loss and Alteration Ice Roads/Pads; Snow Dumps, and Snow Drifts	Low	Local	Temporary (but continues uninterrupted through construction and operation)	Affects all species, but of concern primarily for waterfowl, shorebirds, and passerines	Minor
Gravel Mining and Placement	High	Local	Permanent	Affects many species (depending on habitats affected; permanent habitat loss)	Minor
Obstruction of Flow	Low	Local	Temporary/permanent (unless corrected)	Affects many species (temporary/permanent habitat loss)	Minor
Dust Fallout/Thermokarst	Medium	Local	Temporary/permanent	Affects bird species using habitats near roads/pads	Minor
Spills, Leaks, And	High	Local for terrestrial	Long-term/permanent	Affects most species	Minor/moderate (level of

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Contamination		spills (large spills into the marine environment could have regional effects)	effects on habitats	(particularly those nesting in affected habitats)	effects would vary depending on the nature of the spill)
Disturbance Effects Noise Effects	High (high levels during construction, noisy equipment in use; both in nearshore winter ice roads and onshore gravel roads year-round)	Local	Temporary (but continues uninterrupted through construction and operation)	Affects most species, primary concern for species using habitats near roads	Minor/moderate
Aircraft Disturbance	Medium to high (varies based on location and altitude)	Local	Temporary (variable by season)	Affects species near airstrip or along flightpaths	Minor/moderate
Vehicular Traffic Disturbance	Low to medium (varies based on vehicle type)	Local	Temporary (variable by season)	Affects species near roads	Minor/moderate
Marine Vessels & Barge Landing Site Disturbance	Low to medium (varies based on vehicle type)	Local	Temporary (summer season)	Affects species in nearshore waters	Minor/moderate
Mortality Effects Spills, Leaks, And Contamination	High	Local (large spills into the marine environment could have regional effects)	Long-term/permanent	Affects most species	Minor/moderate (level of effects would vary depending on the nature of the spill)
Increased Predation	Low	Local/regional	Temporary (but continues uninterrupted through construction and operation)	Affects species differently; beneficial for predatory/scavenging birds, detrimental for their prey species and most other species	Minor/moderate
Operation					
Habitat Loss And Alteration Snow Dumps And Snow Drifts (Ice Roads May Be Used Periodically In The Nearshore Or On Land During Operations For Transport Of Equipment Or Pipeline Maintenance)	Low	Local	Long-term	Affects all species, but of concern primarily for waterfowl, shorebirds, and passerines	Minor
Obstruction Of Flow/ Dust Fallout	Low	Local	Long-term	Affects bird species using habitats near roads/pads	Minor
Thermokarst	Low	Local	Long-term/permanent	Affects bird species using habitats near roads/pads	Minor
Disturbance Effects Noise	Low (low levels from vehicles during operation, moderate/high for facilities;	Local	Long-term	Affects most species, primary concern for species using habitats near roads or facilities	Minor (traffic noise) / moderate (facility noise)

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
	noise occasionally also in nearshore winter ice roads)				
Aircraft Disturbance	Medium to high (varies based on location and altitude)	Local	Temporary (variable by season)	Affects species near airstrip or along flightpaths	Minor/moderate
Vehicular Traffic Disturbance	Low to medium (varies based on vehicle type)	Local	Temporary (variable by season)	Affects species near roads	Minor
Marine Vessels & Barge Landing Site Disturbance	Low to medium (varies based on vehicle type)	Local	Temporary (summer season)	Affects species in nearshore waters	Minor/moderate
Mortality Effects Spills, Leaks, And Contamination	High	Local	Long-term/permanent	Affects most species	Minor/moderate (effects would vary depending on the nature of the spill)
Flaring	High (although rare events)	Local	Temporary	Affects species in immediate vicinity of flare	Minor (based on rarity)
Increased Predation (Human/Animal Interaction)	Low	Local/regional	Long-term	Affects species differently; beneficial for predatory/scavenging birds, detrimental for their prey species and most other species	Minor/moderate
Collisions With Vehicles/ Infrastructure	High	Local	Long-term/permanent	Affects most species	Minor

Notes:
1 Intensity (severity) = low, medium, high
2 Scope / Magnitude (geographic) = local, regional, national/international (e.g., for migratory species)
3 Duration = temporary, long-term, permanent
4 Context = common, important (swans, brant, snow geese), unique (none)
5 Overall = none, minor, moderate, major. The effects being assessed for each project activity/component are: 1) long-term habitat loss from gravel extraction and stockpiling at the mine site and gravel placement for the construction of three gravel pads, the airstrip, and the interconnecting road system; 2) temporary habitat loss from soil compaction, disturbance of vegetation, and persistent accumulation of snow and ice following the use of temporary ice roads and work pads; 3) changes in the use of habitats altered by dust fallout, gravel spray from snow removal, persistent snow drifts, thermokarst, water flow alteration and impoundments, water withdrawal, and contaminants; 4) behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats; 5) attraction to project facilities (e.g., herbivorous birds to areas of early snowmelt in spring, predatory and scavenging birds to artificial food sources); 6) increased mortality from predator populations if predators increase as a result of the availability of anthropogenic foods, 7) injury and mortality of birds from vehicle collisions, collisions with overhead wires, towers, or facility buildings, and from contact with or ingestion of contaminants, and 8) long-term habitat loss due to accidental spills.
* This table present anticipated effects of the Project and does not include major spills or well blowouts.

Ice roads are expected to be used during the Construction phase of the Project for winter pipeline construction, and to move materials and, possibly, facility modules from Prudhoe Bay to the Project area. Ice roads potentially could be used on an occasional basis for pipeline maintenance throughout the life of the Project. As discussed above for the Drilling phase, ice roads can result in temporary loss of habitats for some birds. The effects of ice roads on birds during the Construction phase are likely to be identical to those described for the Drilling phase and the level of effect would be similar.

Obstruction of Flow

Impoundments (and other alterations of water flow) can occur when drainage is impeded adjacent to roads or pads. Impoundments can be temporary, disappearing by mid-June, or they can persist throughout the summer. Depending on the duration of seasonal impoundments and the size (magnitude) of the impoundment, the effects on bird habitats can be substantial. Water impounded by gravel roads and pads can both displace and attract birds, depending on the species (Troy 1986; Kertell and Howard 1992; Kertell 1993, 1994; Noel et al. 1996). Temporary impoundments preclude nesting by some species (Walker et al. 1987) but may be used by others (for example, Pacific loon [Kertell 2000]; geese, loons, and 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 (phalaropes) 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). Culverts could 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 Project and the effects associated with obstruction of flow are considered to be minor, given the mitigation measures in place to ensure that impoundments and alterations of flow do not occur.

Dust Fallout

Advanced snowmelt, as a result of dust fallout from vehicular traffic on gravel roads and pads, has both positive and negative effects on wildlife. Advanced snowmelt often impounds runoff and causes early “green-up” of plant species (Makihara 1983; 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; 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, 1988) noted that dust fallout benefited shorebirds within 150–300 feet (46–91 meters) of roads when traffic was relatively light, because it melted snow and made habitats available earlier for nesting. However, at higher traffic levels, vehicular disturbance offsets these benefits, resulting in lower densities of nesting shorebirds (Troy 1988).

Dust fallout associated with gravel regrading and compacting during the first year of summer construction likely would occur after spring thaw and thus would not affect snowmelt. However, construction activities in the following winter and spring likely would result in dust fallout persisting into spring and affecting snowmelt. Advanced snowmelt caused by dust fallout adjacent to roads, pads, and the airstrip could result from construction activities. Watering the roads during the summer and enforcing vehicular speed limits at all times would mitigate potential effects from dust fallout. In summary, because habitat changes that result from dust fallout can have both beneficial and detrimental effects on birds, and these effects are of low intensity and have a relatively small geographic effect, the overall effect (either positive or negative) of dust fallout on birds is considered to be minor.

Thermokarst

Thermokarst is a natural phenomenon, as well as a potential effect from road and gravel pad construction and associated dust fallout, that can alter the tundra landscape by inducing changes in microrelief and soil moisture. Changes caused by 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). Among the bird groups known to occur in the Project area, geese are strictly herbivorous and selectively graze plants of higher nutritional value and have been regularly observed grazing in thermokarst terrain adjacent to facilities in the existing oil fields (Murphy and Anderson 1993). However, the effects of tundra disturbance on secondary production (i.e., production of herbivores such as geese) 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 overall effect of thermokarst on wildlife populations (Truett and Kertell 1992). Thus, the effect (either positive or negative) of thermokarst on birds is considered to be minor.

Snow Dumps and Snow Drifts

During the Construction phase, any snow dumps and snow drifts 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. Because large accumulations of snow are not anticipated in the Project area, only a small number of sites are likely to be potentially affected by snow dumps and snow drifts. In addition, mitigation measures, such as ensuring that snow is stored on the gravel surface as much as possible and relocating snow-dump areas from year to year, would minimize any long-term effects on nesting habitats. Also, because nesting habitat is not a limiting factor, population-level effects on birds are not anticipated; thus, the overall effect of snow dumps and drifts is considered to be minor for birds.

Spills, Leaks, and Contamination

Contaminant spills (oil and other products) and clean-up efforts can alter bird habitats in various ways (for example, loss of vegetation, decreased plant productivity, scuffing of vegetation during clean-up). The most common spills are relatively small in quantity, however, and usually are contained on gravel pads. Larger spills are more often associated with pipeline or facility failures and are discussed below in Section 4.2.4.3, Operations. Small spills in the Project area during the Construction phase are not anticipated to cause population-level effects on birds attributable to habitat alteration, thus the overall effect on birds would be minor.

Sealift Barge Offloading System

Construction of the barge offloading system at the Central Pad to support the sealift of facility modules and other equipment likely would result in some temporary and periodic loss of habitats for birds using the nearshore waters. Construction of the five offshore mooring dolphins would occur through the ice in winter, permanently affecting a small amount of benthic habitat. Dredging and screeding required to allow landing/grounding of the first three barges in the barge bridge would directly affect benthic habitats between the Central Pad and about 400 feet (122 meters) offshore. Dredging would be by backhoe from the ice surface during winter or from a barge with spuds to hold it in place during open water seasons. Dredged materials would be transported by truck via ice roads in winter or by barge during open water seasons to designated shore based areas for disposal. If possible, dredged material would be used were appropriate for beach nourishment. Temporary dredge storage sites, beach nourishment sites, and truck access routes to storage or nourishment sites have not been determined, but may result in additional loss or disturbance of terrestrial and benthic habitats. Dredging in the nearshore benthic habitats may affect the populations of invertebrate prey or their availability to birds (such as Long-tailed Ducks or loons) foraging in these nearshore areas during the summer months. The size of the dredged area is small, but the size of the resulting plume during summer months in uncertain. In summer, the resulting turbidity plume could temporarily displace birds foraging or loafing in the affected nearshore waters. For example, Long-tailed Ducks occur in the nearshore waters near the Project site during the molting and post-molting periods (mid-July–mid-September) and commonly feed on benthic invertebrates that may be temporarily unavailable if covered by a silt plume. Overall, the expected effects on birds from temporary loss or alteration of bird habitats by the sealift landing options is considered to be minor, as the amount of disturbed benthic habitats is small, the effect is expected to be temporary and, if most construction is in winter, the effects on habitats should dissipate before most birds use the area; thus, this effect is considered to be minor.

Disturbance Effects

Potential disturbance effects during the Construction phase include immediate behavioral responses of affected birds (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).

Noise Effects

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, 1988; Anderson 1992; Anderson et al. 1992; Burgess and Rose 1993; Murphy and Anderson 1993; Johnson et al. 2003). Birds can be sensitive to noise disturbance during any life-history stage; however, nesting birds, which are restricted to one site for up to four weeks, are especially susceptible to disturbance during that period and such disturbances can lead to nest failures or decreased productivity. The earliest nesting birds (swan, geese, ducks, and shorebirds) typically initiate nests sometime after 1 June, and all but a few species hatch by 15 July. Therefore, during this period (1 June–15 July) the consequences of behavioral disturbance of birds may be most severe (that is, loss of productivity). Following nesting, many birds typically move with their young from nest sites to other locations and use different habitats, and thus are more capable of moving away from (avoiding) disturbance sources (for example, airstrips or roads), if necessary. Overall, the effects of noise on birds are likely to be greatest during the periods when construction activities overlap with the breeding season and nesting birds are unable to move in response to local increases in noise. These effects would be temporary, of short duration, but intensity could be high in small areas, thus noise disturbance would have a minor to moderate effect on birds.

Aircraft Disturbance

During the summer construction period, helicopters and fixed-wing aircraft are expected to be used to move equipment and personnel from Endicott/Prudhoe to the Project area. Until construction of the airstrip in winter 2011, helicopters would provide the only summertime aircraft access for personnel to the Project area. Marine vessels (barges and smaller support ships) from Endicott/Prudhoe also would be used to support summer construction. Vehicular traffic would occur on the infield road system as construction on the roads is completed, and some traffic would be expected daily at the Central Pad and between the gravel mine site and the Central Pad. Projected air and vehicle traffic rates for the Construction phase of the Project have not been determined. Noise from these activities, and the physical presence of the equipment both onshore and offshore, could disturb birds in the Project area.

Air traffic associated with the Project could result in behavioral disturbance of birds. Noise levels and potential for disturbance would be highest during take-offs by large aircraft and helicopters. Based on U.S. Air Force (USAF) data (OMEGA 10.8 noise model) (Mohlman 1996), the area affected by the highest noise levels during take-off by a Boeing 737-200 (an aircraft that could use the Point Thomson airstrip, although smaller aircraft are more likely to provide access to the area) can be approximated by a zone extending to 6,300 feet (1,920 meters) around the runway (4,947 acres [20.0 square kilometers]), within which noise levels could reach or exceed 85 dBA as the engines reach maximum power. Noise levels during landings would be substantially lower than during take-offs, although the aircraft would be at lower altitudes during a longer approach to the airstrip.

The effects of large fixed-wing aircraft on wildlife were not thoroughly studied in the Arctic until recently. Most older studies of aircraft disturbance in the Arctic focused instead on low-flying helicopters (LGL 1974; Barry and Spencer 1976; Simpson et al. 1980; 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 many 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 aircraft disturbances (primarily helicopters) than to constant (steady-state) disturbances, such as Twin Otter and 737 aircraft (Murphy and Anderson 1993). Investigation of effects of the airstrip at the Alpine oil field indicated that few nesting birds appeared to be negatively affected by aircraft operations at the airstrip; however, in the heavy construction years, when aircraft traffic was greatest, Greater White-fronted Geese did show shifts in nest distribution away from the airstrip (Johnson et al. 2003). Distance of nests from the Alpine airstrip did not have a significant effect on nesting success of swans and geese, although it may have affected nest attentiveness, with some birds taking more frequent or longer recesses at nests closer to the airstrip.

The proposed siting of the Point Thomson airstrip could result in flight patterns over the offshore lagoon area (Lion Bay) that is used by thousands of molting and feeding birds each summer during July–September (Noel et al. 2000, 2001a, 2002b; Flint et al. 2001, 2002). 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 about 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 mile (1 kilometer). However, a continuation of that study found little effect of human disturbance on the densities and distribution of Long-tailed Ducks in the Project region (Fischer et al. 2002).

At the Project site, aircraft traffic is anticipated to be greater during winter than during the summer in both the Construction and the Operations phases, which should reduce adverse effects because few birds are present in winter. In summary, although disturbance by Project-related air traffic and noise would be unlikely to measurably reduce the distribution, abundance, and productivity of most breeding birds near the airstrip, behavioral disturbance of birds by low-flying aircraft nearshore and over Lion Bay, although infrequent, would be persistent and would affect a relatively large geographic area; thus, the overall effect on birds would be considered to be moderate along the coast.

Vehicular Traffic

Vehicle traffic would occur on the infield roads after construction and compaction are completed. Projected vehicle traffic rates during the Construction phase of the Project have not yet been determined.

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 bird predators). In general, the frequency of bird reactions to vehicles increases with traffic rate, although—at consistently high traffic rates—birds may become habituated and react to fewer individual vehicles. Even at higher traffic levels, reaction rates remain high to particularly large, noisy vehicles (gravel-hauling trucks), and those with unusual profiles, such as boom cranes (Murphy and Anderson 1993).

Reactions of birds to vehicular traffic can 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 500–700 feet (152–213 meters) of roads and pads in the Lisburne area (Murphy and Anderson 1993). Approximately 10 percent of all vehicle passes elicited reactions from geese and swans (Murphy and Anderson 1993; 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). A recent study at the Alpine oil field on the Colville River Delta found that birds reacted less to vehicular traffic than they did to pedestrians and airplanes (Johnson et al. 2003); the Alpine oil field is more similar to the Project than the older oil fields of Prudhoe and Kuparuk because it is a “road-less” development with only a few drilling pads and an airstrip connected by a short road system.

On the basis of these results, a small percentage of birds likely could show short-term alterations in their behavior as a result of summer construction disturbances. Minor effects on nesting success from disturbance within 700 feet (213 meters) of drilling pads (229 acres [0.93 square kilometers]) and within 500 feet (152 meters) of gravel access roads (1,371 acres [5.55 square kilometers]) also are possible (the airstrip is excluded from these calculations, but an additional area also would be affected). During the Construction phase, disturbance would be highest during summer, when traffic rates would be higher and larger, noisier vehicles (for example, gravel-hauling trucks) would be more likely to use the infield roads. However, most construction activities involving ice-road construction and gravel hauling and placement would take place in the winter, when few, if any, bird species are not in the area. In summary, although most vehicular disturbances to birds tend to be of short duration, this type of disturbance is chronic in oil field developments and would have an overall minor to moderate effect on birds.

Marine Vessels and Sealift Landing Site Disturbance

During the Construction phase, marine vessel traffic at the Project sealift landing site could disturb birds using Lion Bay and nearshore waters, particularly Long-tailed Ducks and other waterfowl. Use of the sealift landing site 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 Lion Bay, between approximately 20 July and 30 September (Noel et al. 2000; Fischer et al. 2002; Flint et al. 2002). Petersen et al. (1999) found that Long-tailed Ducks were disturbed (dove or scattered) by boats approaching within 0.6 mile (1 kilometer), but often returned to the same area after the disturbance had passed, suggesting that occasional disturbances did not have long-term effects. The greatest potential disturbance to birds would occur during the proposed sealift in late summer 2012–2014. However, the effects could be mitigated by scheduling the sealift later in the summer (after mid-August) when almost all birds are flight-capable and would be able to easily redistribute their use of the lagoon system to avoid slow-moving barges. In general, the overall effect of disturbance from marine vessel traffic on birds would be minor, because it would occur infrequently and the intensity of the effect would be low, but this disturbance may increase to moderate levels during sealift operations, if they occur during the molting period.

Noise and visual disturbance from the construction of the barge offloading system or emergency boat launch ramp, including summer dredging or installation of pilings, may temporarily displace birds from the immediate construction area, which might offset some of the effects of the dredging sediment plume on foraging activities in the nearshore, although if the plume itself alters longer-term food availability or disturbs benthic fauna, then effects may persist past the initial disturbance. The overall effects of disturbance from construction of the barge offloading system on birds would be minor to moderate, depending mainly on the timing of dredging. If construction activities and dredging occur during summer when birds are present in the nearshore and if foraging or roosting habitats are affected by disturbance, then moderate effects would be anticipated for birds using nearshore habitats in the Project area.

Freshwater Pipeline

Construction of the freshwater pipeline to the Central Pad, initially from the C-1 site and later from the reservoir created by the gravel mine, likely would inhibit free movement of flightless young birds and flightless brood-rearing adult waterfowl. Current plans call for an insulated pipeline approximately 8 inches (20 centimeters) in diameter resting on sleepers on the tundra, yielding an overall height of approximately 20 inches (51 centimeters) above grade, suggesting an average of approximately 12 inches (31 centimeters) of clearance between the bottom of the pipe and the ground. This pipeline would provide fresh water to the Central Pad camp during the Construction and Operations phases. The route of the freshwater pipeline has not been determined, but likely would parallel proposed gravel access routes between the reservoirs and the Central Pad almost due north. Any flightless birds moving east or west between the airstrip on the south and the Central Pad on the coast would be required to cross the gravel access road and then the surface mounted freshwater pipeline. Although the reactions of birds to the pipeline cannot be predicted with certainty, the effects of the freshwater pipeline on birds are likely to be minor, possibly funneling larger birds (such as waterfowl—swans, geese, and ducks) towards facilities but eventually allowing passage where terrain creates greater clearance. If there are areas where the water pipeline inhibits the movement of flightless birds, they could spend greater time between the gravel road and pipeline, possibly increasing the number of road crossings and associated hazard. The distance between the water sources and the Central Pad is 3–4 miles (4.8–6.4 kilometers) and the density of nesting waterfowl in the Project area is moderate, suggesting that the number of birds affected is likely to be small. Smaller shorebirds and passerines are less likely to be affected. Overall, the effects of the freshwater pipeline on birds are anticipated to be minor.

Mortality Effects

Bird mortality associated with the *Construction* phase activities would be similar to that described previously for the Drilling phase, but the extension of construction activities into the summer months could increase the potential for collisions of birds with infrastructure (facilities, towers), aircraft, and vehicles. Although the proposed sealift landing structures—the permanent dolphins and annually grounded barge bridge—extend only approximately 1,200 feet (366 meters) into the nearshore waters off the Central Pad, these structures are elevated slightly above the sea surface and thus pose some minor risk for collision by birds (eiders, loons, ducks) flying low along the coast during migration or during local flights within the area.

Erected during the Construction phase, the communication towers for the Project would present a collision hazard for birds. One communication tower would be located on the Central Pad and will be 160–200 feet tall (49–61 meters). The design of this tower has not been determined, but both guywires and trestle structures present collision hazards. An additional communication tower would be located either at Badami or at the ExxonMobil pad in Deadhorse. No design details are available for the secondary tower. The Badami site, however, is likely to present greater avian collision hazard than would the Deadhorse site because of its proximity to coastal migration paths. Although these towers likely would result in minor effects on birds, some collisions and mortality are possible, particularly during migration when large numbers of birds move along the coast and weather and visibility often are poor. Data on the flight altitudes and flight paths and numbers of migrating birds are lacking for the Central Pad site, so the magnitude of hazard cannot adequately be assessed. Collision hazards for birds are discussed more fully in Section 4.2.4.3, Operations.

Other potential sources of bird mortality associated with the Construction phase might include mortalities from oil or contaminant spills from vehicles or marine vessels. Most small spills are likely to be cleaned up before they could affect most birds. The greatest potential for mortality would be from a larger-scale spill in the nearshore waters during marine activities associated with construction of the barge landing site and during marine vessel travel between Prudhoe Bay and the Project area. Attraction of predators to the Project during the Construction phase and any subsequent increase in the predator population might be an additional source of potential mortality for birds. Managing predator populations through the worker education and waste-handling practices currently in use on the North Slope likely would help reduce this potential source of increased mortality for birds. Overall, the effects of Construction phase activities that might affect bird mortality are considered to be minor, but could increase to major for any catastrophic spill event, particularly in the nearshore marine waters of Lion Bay or the Beaufort Sea.

4.2.4.3 Operations

Some limited use of ice roads to access the Project area may occur during the Operations phase (see discussion of the effects of ice roads on birds in Sections 4.2.4.1, Drilling and 4.2.4.2, Construction).

Habitat Loss and Alteration

The effects of gravel placement, obstruction of flow (impoundments), thermokarst, and dust fallout on birds have been described above for the Construction phase. Most of those effects are likely to continue during the Operations phase.

Disturbance Effects

Birds can be sensitive to noise disturbance during any life-history stage, but during nesting, when birds are restricted to one site for two to four weeks, disturbance that results in decreased nest attendance can lead to abandonment and nest failure. The earliest tundra-nesting birds (waterfowl and shorebirds) on the coastal plain typically initiate nests sometime after 1 June, and all but a few species hatch by 15 July. Common Ravens and raptors often nest earlier (April–May) than waterfowl, particularly those species using elevated nesting platforms that may become snow-free or, in the case of ravens, artificial nesting sites on buildings or towers. Behavioral disturbance during this critical period is likely to have the most severe consequences for breeding birds (i.e., loss of productivity). Following nesting, birds typically move with their young away from nest sites to other locations and use different habitats. During this brood-rearing period, most birds are more capable of moving away from disturbance sources (e.g., airstrips or roads), if necessary, but such movements may make young more vulnerable to predators or increase energetic demands on young and adults. Many waterfowl, however, also undergo a molting of flight feathers during the same period when they are rearing young, which makes them incapable of flight and less able to respond to some disturbances by rapid movements away from the source of disturbance. After brood-rearing and molt are completed, many birds merge into larger flocks in preparation for fall migration and some species (waterfowl and shorebirds) congregate in coastal habitats, which can make them vulnerable to disturbance in those areas.

Noise Effects

During the Operations phase, habitats located adjacent to roads, airstrips, or pads could become less attractive to birds and, therefore, would be avoided, as a consequence of both vehicular traffic disturbance and increased noise levels. For some species, high noise levels (for example, during drilling or 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 did decrease 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 waterbird species (Spectacled Eiders, pre-nesting Canada/Cackling geese, brood-rearing Tundra Swans) to shift their distribution (averaging 1,600 feet [488 meters] to 2,000 feet [610 meters]) away from habitats close to the compressor plant, although most waterfowl species (including nesting Canada/Cackling Geese, Brant, Greater White-fronted Geese, loons, and ducks) habituated to the higher 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 mile (0.8 kilometer) of the facility, a nesting colony of Brant, located approximately 0.5

mile (0.8 kilometer) away, has not been affected adversely by the constant noise emanating from the facility; this nesting colony has been used continuously since facility operation began (Stickney et al. 1994; Anderson et al. 1995, 1996; Anderson 2009). These studies suggest that some birds may be displaced from the immediate area (within 0.5 mile [0.8 kilometer]) surrounding the gas processing facility. In general, the size of the displacement area would depend on the species and the magnitude and nature of the noise generated by facility operations. In summary, the noise associated with processing facilities could have an overall minor to moderate effect on birds because of the chronic nature of the disturbance.

Aircraft Disturbance

Once operation of Project facilities commences, the level of most disturbing activities to birds should decline. For example, aircraft, marine vessel, and vehicle traffic on infield roads are all projected to decline with the start-up of operations at the Project facility. Projected aircraft operations for the Operations phase of the Project have not yet been determined.

Projected estimates may be low, however, given the actual aircraft operations reported for the Alpine oil field (a similarly sized project) during just part of the summer of an operational year (1 June–15 July 2001), when summer air traffic averaged six daily round-trips by small aircraft, one daily round-trip by a medium cargo aircraft, and eight daily round-trips by helicopter (Johnson et al. 2003). Thus, levels of likely disturbance to birds from aircraft traffic could be more variable than initially estimated. As during the Construction phase, the overall effect on birds from aircraft overflights and the proposed airstrip during the Operations phase would likely be moderate, although this effect may decrease to minor if the lower levels of air traffic are achieved.

Vehicular Disturbance

Projected traffic rates for the Operations phase of the Project have not yet been determined. However, daily vehicular traffic on infield roads between pads would occur at somewhat higher levels during the first operational years, because drilling would still be ongoing on some well pads. These vehicular traffic levels would decline after drilling is completed in 2010.

Levels and duration of noise from drilling and from operations equipment (such as compressors, generators, and flares) proposed for the Project have not yet been characterized, but could disturb birds in the area. Some habituation of birds to road traffic would be expected over time (as has occurred in the Prudhoe Bay oil fields; Murphy and Anderson 1993), thus overall effects on birds from vehicular disturbance during the Operations phase is expected to be minor.

Marine Vessels and Sealift Landing Site Disturbance

Projected marine traffic rates for the Operations phase of the Project have not yet been determined.

During the Operations phase, vessels using the proposed marine sealift landing facility at the Project site could displace molting Long-tailed Ducks, and perhaps other birds, that regularly use that area during late summer (Noel et al. 1999a, 2000, 2001, 2002b). Mean numbers of Long-tailed Ducks observed during aerial surveys along the mainland shore in the Project area have ranged from 142–530 birds per square mile (55–205 per square kilometer), but peak counts can exceed 2,000 birds (Table 3-28). Displacement of birds in late summer would be highest when boat/barge traffic would occur, or when oil spill drills would be held. Although it is unknown whether such displacement would be long-term, Petersen et al. (1999) found that Long-tailed Ducks that moved in response to disturbance by boats in the Project vicinity did eventually return to the same area. Thus, the overall effect from marine vessels during the Operations phase would be minor, given the limited occurrence and short duration of this disturbance type.

Mortality Effects

Spills, Leaks, and Contamination

Contaminant spills (oil or other products) also have the potential to cause bird mortality during the Operations phase. Contaminants can adversely affect birds through contact with feathers or skin, dermal absorption, ingestion, or inhalation. Contact with feathers or skin can affect the ability of feathers to insulate or to shed water, leaving birds susceptible to hypothermia. For small spills, the chance that many birds would be oiled is limited because of the size of the spill, but seasonal timing of spill events and their location relative to high-use habitats may increase chances that birds would contact spilled oil or other petroleum products. The most common oil field spills (small-volume spills of fuels and vehicle/machinery lubricants) are unlikely to have population-level effects on birds. These types of spills are likely, however, and can cause mortalities to any birds affected, but overall effect is expected to be minor (limited numbers of birds affected). The relative effect of larger contaminant spills is considered in detail in Section 4.4, Spill Response. However, the effects of larger spills can be much greater and may increase the level of overall effect on birds to a major level, particularly if large numbers of birds or a large area of tundra or nearshore habitat are affected. The magnitude of a major oil spill would be dependent on the location and seasonal timing of the spill. The spill scenario that would be most likely to cause major effects on birds would be a large spill in Lion Bay in late summer when large numbers of molting and non-breeding waterbirds (ducks, gulls, eiders, loons) are present and when at least some are flightless (undergoing wing molt), thus inhibiting their ability to fly away from a spreading oil spill.

Collisions with Vehicles or Infrastructure

Collisions of birds with vehicles (trucks and aircraft) and structures (buildings, flare stacks, or communications towers) pose some risk of mortality to birds in the Project area. The risk of birds being hit by vehicles is greatest during summer, when larger numbers of birds are present and moving in the Project area. Herbivores, such as geese and ptarmigan, can be attracted to roadside habitats by early green-up and higher nutrient forage. Both geese and ptarmigan also frequently will rest on gravel roads or pick up grit necessary for the physiological processing of forage. Although these birds gain access to nutritious forage near roads, 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. Numbers of mortalities can be reduced by requiring slower vehicle speeds during periods when birds are attracted to roads and minimizing attractive habitats (impoundments) near roads.

Waterfowl and other birds occasionally collide with oil field structures, including buildings and towers, antenna guy-wires, and power poles and wires (Day et al. 2007). Bird strikes are most common in areas where large numbers of birds aggregate or pass through 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 caused by fog or darkness. Anderson and Murphy (1988) studied bird strikes with power lines in the Lisburne development area in Prudhoe Bay and found that most collisions apparently occurred under conditions when visibility was limited. Species in the Project area that could experience strikes with Project facilities include Long-tailed Duck, Common Eider (possibly King Eider), and Brant, all of which would be abundant in the area during molting or migration periods. Other species of waterfowl (particularly Snow Geese) and shorebirds that migrate primarily along the coast could also be subject to occasional strikes.

Predicting the likelihood of bird strikes at a particular site is difficult without having detailed knowledge of local bird movements during migration. Although this information is lacking for the Project site, the potential for bird strikes having population-level consequences is likely to be limited 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 effects of the facility for recreational users of the area (see Section 4.3.6, Recreation and Section 4.3.7, Visual Aesthetics). Both the buildings and the communication towers could have lighting installed to reduce bird attraction and the potential for bird strikes. A recent study at Northstar Island (a man-made drilling island near Prudhoe Bay) suggested that installing “anti-collision” lighting on buildings did cause slight reductions in attraction by some migrating birds, but the effect was not universal for all species and, in some cases, the lights appeared to attract some birds (Day et al. 2003). Whether such a system would be effective at onshore facilities is not clear, but bird strikes with buildings on the coast have been reported at Prudhoe Bay (Day et al. 2003). As discussed under Construction, the sealift landing structures pose some minor risk for collision by birds (eiders, loons, ducks) flying low along the coast during migration or during local flights within the area. In general, the overall effect of mortalities to birds from vehicles, buildings, and towers is expected to be minor, given the low likelihood of occurrence.

Flaring

The immediate vicinity of the flares at the Project site would be fenced, therefore mortality of or injury to flightless or molting birds is unlikely. Mortality would be more likely for birds flying near or through the flare. Although a bird flying into a flare is likely to be a rare event, it has been recorded in the oil fields (a Peregrine Falcon was injured by flying into a flare at Prudhoe Bay [Ritchie ND]). Day et al. (2003) found that gas flaring on Northstar Island during one night when the flare was operated for several hours at a high level acted as an attractant to migrating birds (primarily Long-tailed Ducks and Glaucous Gulls). Generally, flaring would be a relatively rare event and noise associated with the flaring would serve to keep flying birds away from the area during that event; thus, this effect would also likely be minor for birds.

Increased Predation

Additional effects of Project operations would be the effects from the creation and handling of anthropogenic wastes, and the creation of artificial nesting and roosting sites for some species. Glaucous Gulls and Common Ravens are attracted to garbage and food handouts at human settlements and oil field camps. Although adequate historical records are lacking, biologists generally agree that the populations of these two species likely have increased because of the availability of these foods from 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; Powell and Backensto 2009). Raptors, gulls, ravens, ptarmigan, songbirds, and shorebirds all perch on elevated pipelines, and Snow Buntings nest in VSMs and buildings. The presence of Project facilities may cause minor increases in populations of scavenging birds, particularly if any edible garbage is available and accessible to them at the facilities. Snow buntings, raptors, and ravens also may show increased local populations if they are able to nest or roost on new buildings and pipelines built for the Project. Many of these effects can be reduced by proper handling and disposal of camp-generated solid wastes to reduce the attraction factor. Monitoring the use of facilities by nesting species or by eliminating nesting opportunities will also help prevent an increase in scavengers near the facilities. Overall, the expected effect on birds, given proper waste-handling procedures, would be expected to be minor.

Increased predator populations in the vicinity of oil field developments have likely increased predation on bird populations (Martin 1997; Day 1998; Liebezeit et al. 2009). This effect is inferred from the higher numbers and productivity of foxes (Eberhardt et al. 1982; Burgess et al. 1993; Burgess 2000), grizzly bears (Shideler and Hechtel 1995b, 2000), and gulls and ravens (Truett et al. 1997; Day 1998; Powell and Backensto 2009) in the North Slope oil fields. Gulls, ravens, and foxes all prey on bird eggs and young, and foxes also can take adult birds. Grizzly bears are also known to take bird eggs, particularly those of colonially nesting Snow Geese (Johnson and Noel 2005; ABR 2007). Foxes and grizzly bears have caused 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, 2000; Johnson and Noel 2005; Noel and Johnson 2001a, 2001b; Noel et al. 2002a). Failure of the Snow Goose and Brant colonies at Howe Island in six of 10 years was attributed to the increased abundance of arctic foxes and bears in the region (Johnson and Noel 2005; Noel and Johnson 2001a, 2001b; Noel et al. 2002a). Common eiders are the most abundant colonial nesting species in the Project area and are susceptible to arctic fox predation during nesting (Quinlan and Lehnhausen 1982; Noel et al. 2002c).

A recent study of effects of predators and oil field infrastructure on tundra-breeding birds on the ACP found that passerines (primarily Lapland Longspur) experienced an increase in risk of predation within 3.1 miles (5 kilometers) of human infrastructure, but no effect was detectable for shorebirds as a group, although phalaropes did show lower productivity near infrastructure and where predator populations were higher (Liebezeit et al. 2009). Human-refuse control efforts, employee environmental sensitivity training, and enforced rules against animal feeding should minimize population-level effects on predators and scavengers, and avoid the potential for these animals to negatively affect bird populations in the Project area. The overall effect on birds from potential increases in predator populations is considered to be minor as long as proper waste-handling procedures are followed.

4.2.5 Marine Mammals

The environmental consequences of the Project to marine mammals are described for drilling, construction, and operations. Subsistence is addressed at the end of the section and is also addressed in Section 4.3.3 in more detail. The Project is expected to have no more than a short-term and temporary effect on a small number of marine mammals, primarily ringed seals. Mitigation measures, including those stipulated by NMFS and USFWS in the incidental take permits for the Project and instituted by ExxonMobil, are expected to result in the Project having no more than a minor effect on the marine mammal populations. See Section 4.2.7, Threatened and Endangered Species, for an analysis on bowhead whales and polar bears.

4.2.5.1 Drilling

Drilling will require transport of materials by barge and ice roads and the transport of workers by aircraft. Drilling will occur during winter and summer (late spring to early fall) on land-based gravel pads and, potentially, ice pads, which are expected to have no effect on seals, walruses, or whales. Barging will occur during summer and involve moving materials from Prudhoe Bay to the site where the barges will be grounded for unloading of materials. Vessels are major contributors to underwater noise (Richardson et al. 1995). The primary source of noise from vessels is created by propeller cavitation, propeller singing, and propulsion. Other machinery, such as engines, pumps and fans also contribute. Sound levels and frequencies of vessels are related to vessel size, design, speed, and load. Source levels of tugs boats pulling barges from West Dock to Point Thomson may range from 145–170 dB re 1 µPa at 1 meter with a frequency range of 37–5,000 hertz (Hz) (Richardson et al. 1995). The source level may vary depending on the barge load.

Noise from vessels could potentially have short-term effects on marine mammals including behavioral disruption or temporary habitat displacement (Richardson et al. 1995). The behavioral responses of marine mammals to vessel noise are highly variable and may depend upon individual hearing sensitivity (animals respond only to sounds they can directly detect), past exposure and habituation to vessel noise, and demographic factors such as the age and sex of the animal. Other factors include the duration of the sound, whether the sound is moving, and environmental factors that affect the sound including habitat characteristics (National Research Council [NRC] 2003).

Barging during this phase will occur inside the barrier islands, where the tugs transporting the barges could encounter small numbers of ringed seals and even fewer bearded and spotted seals. The underwater noise and presence of the tug pushing the barge could cause the seals to alter their location or change behavior, but any effects are expected to be minor because they will be short term, temporary, and limited to a very small number of seals encountered along the transportation route. Grounding of the barges is expected to have no effect on the seals, because it would occur in an area absent of documented spotted seal haul-out sites.

Ice roads will be built and maintained on the sea ice to transport materials but their locations are planned to occur in waters too shallow for use by ringed seals, the species of concern during winter and early spring. The ice roads would be built on ice in water less than 9.8 feet (3 meters) deep, which NMFS has determined is too shallow for ringed seals to enter and leave lairs. Ice roads built and maintained in deeper water could cause ringed seals to abandon lairs or expose pups to mortality. Sea ice road construction in waters over 40 feet (12 meters) deep produced potentially detectable low-frequency (<200 Hz) underwater noise as far as 2,624 feet (800 meters) from the source (Greene 1983). Others have found that sound, especially at low frequencies, attenuates rapidly in shallow nearshore waters (Miles et al. 1987; Richardson et al. 1985). Thus, winter ice road construction sounds will only propagate a short distance in waters as shallow as 10 feet (3 meters) or less.

Ringed seals are sensitive to noise and visual stimulation; however, noise and visual stimulation from winter ice roads and construction will be in areas where ringed seals are not present and far enough away from the seals that they should not be affected by these activities.

During the winter drilling phase, as well as during winter construction, numerous vehicle trips per day could take place on the sea ice road from Prudhoe/Endicott to the Project area. In addition, several helicopter and other aircraft trips could be required each day to support construction activities.

However, mitigation measures routinely stipulated by NMFS in incidental take permits include operator-run surveys for locating and marking lairs along planned ice road locations to establish 328-foot (10-meter) protection buffers, thereby greatly reducing the effects on ringed seal lairs.

Aircraft transporting workers to and from the site could affect marine mammals from spring through fall. Low-flying aircraft and helicopters have been demonstrated to cause temporary and short-term changes in marine mammal behavior (Richardson et al. 1995). Ringed seals basking on the sea ice with pups during spring would be the species most affected by low-flying aircraft. Aircraft noise may cause adults to leave pups on the ice vulnerable to polar bears, which are their primary predators. Implementing proven mitigation measures can prevent effects to ringed seals and other marine mammals. These include avoiding flying over the ice or water and/or flying at altitudes scientifically demonstrated to not disturb marine mammals (greater than 1,500 feet [457 meters]). Flights over ice during winter are not expected to affect marine mammals, because most marine mammals are absent and ringed seals use lairs insulated by snow, which greatly attenuates aircraft noise (Blix and Lentfer 1992); therefore, the potential effects would be considered none to minor.

4.2.5.2 Construction

Construction will have similar effects on marine mammals as described above under drilling, because it will involve the same activities, including barging materials (modules), off-loading materials from grounded barges, building ice roads, and flying workers to and from the site. In addition, a barge dock will be constructed at the Project site to offload modules. These activities will likely occur more frequently and for longer periods of time over multiple years, and there will be increased airborne noise levels from construction of the facility. During pile driving, crews will cut holes into the ice and then drive the piles into the sediment below. Potential effects, however, are still expected to be short-term, temporary, and primarily limited to small numbers of seals, particularly ringed seals.

Increased vessel traffic is expected to potentially expose marine mammals to disturbance more frequently than drilling. Seals would be the primary marine mammal affected by construction, because other marine mammals would occur beyond the barrier islands, except for the possible but unlikely occurrence of a bowhead or beluga whale. All three seal species would be present in low densities along the marine transportation routes during open water activities, and a bowhead or beluga could stray inside the barrier islands during late summer or the fall migration.

When the sea is ice-covered, ringed seals and the remote possibility of a bearded seal would be the only marine mammals present, because all other marine mammals winter in the Bering Sea. Effects from increased traffic on the ice road on these marine mammals are expected to result in short-term and temporary disturbances in behavior, as reported in a number of studies (Richardson et al. 1995; LGL and Greeneridge 2001). Construction noises typically occur at frequencies below those detected by seals (less than 1,000 Hz) (Richardson et al. 1995).

Implementation of mitigation including vessels altering courses to avoid marine mammals, aircraft flying above altitudes known to not cause disturbance to marine mammals, and establishing protective buffers around seal lairs in winter is expected to reduce effects to none to minor level.

Construction will expose seals to higher levels of airborne noise than drilling because of the equipment used to build the facility. However, noise levels will be greatly moderated and commonly overwhelmed by ambient noise caused by persistent winds in the Project area as reported at the BPXA Northstar Development (Blackwell et al. 2004). Airborne noise is expected to most likely affect small numbers of ringed seals basking on sea ice during spring near the construction area. Seals near the construction during summer to early fall might change their behavior by looking at or moving away from the noise source. However, studies at Northstar have shown that construction noise had no noticeable effect on ringed seals (Blackwell et al. 2004). Airborne noise has not been demonstrated to have any effect on whales.

4.2.5.3 Operations

Operations are expected to have similar effects on marine mammals as construction, because they will involve many of the same activities, with the addition of potential oil spills. Operations are expected to affect seals during open water season, possibly an isolated occurrence of a beluga whale during late summer or the fall migration, and ringed seals when the sea is ice-covered during winter and spring. Similar to construction, operations effects are expected to be temporary, short-term, and limited to a small number of marine mammals, primarily seals, and would therefore be considered no more than minor. A very small proportion (less than 1 percent) of the seal populations is expected to be exposed to operations activities, because seals are widespread during summer and fall, as are ringed seals during spring and winter. Other marine mammals primarily occur beyond the barrier islands, where they are widely distributed over the OCS. Implementation of mitigation measures described for drilling and construction is expected to result in operations having no more than a negligible effect on marine mammals.

An oil spill during operations may affect ringed seals, particularly during spring break-up of the sea ice. Oil could become trapped among the floating ice used by ringed seals. Oil is difficult to recover in broken sea ice compared to solid ice, open water, or on land. Any spill may affect a small number of ringed seals through oil ingestion or fouling of fur. However a spill would be limited to a small area of the total ringed seal habitat in the Beaufort Sea. Historically, most spills during operations have been small and quickly contained by the oil and gas company. In addition, the oil and gas companies have oil spill response teams highly trained in spill containment and recovery. Warning systems are also in place for operators to quickly detect a spill and respond. Both the spill response teams and warning systems are expected to prevent most spills from becoming large enough to have an effect on marine mammals. Therefore, potential effect of an oil spill on the marine mammal populations would be minor.

4.2.5.4 Indirect Effects on Subsistence

Subsistence activities by the two closest villages (Nuiqsut and Kaktovik) occur considerably beyond the Project area and planned marine transportation corridors. Seals are generally hunted close to these villages, a considerable distance from the Project site, so few hunters may be encountered during the three phases of the Project. Furthermore, bowheads and belugas migrate beyond the barrier islands, so the Project should not have any effect on the fall migration, which is when the two villages hunt whales. Therefore, the Project should have no more than a minor indirect effect on subsistence hunting of marine mammals.

4.2.6 Terrestrial Mammals

The Project is likely to have the following effects on terrestrial mammals (Table 4-22):

- <u>Long-term habitat loss</u> from gravel extraction and stockpiling at the mine site and gravel placement for the construction of three gravel pads, the airstrip, and the interconnecting road system;
- <u>Temporary habitat loss</u> and long-term habitat alteration from persistent accumulation of snow and ice, soil compaction, and disturbance of vegetation following the use of temporary ice roads, work pads, snow dumps, and associated snow drifts;
- <u>Changes in the use of habitats</u> altered by dust fallout, gravel spray from snow removal, persistent snow drifts, thermokarst, water flow alteration and impoundments, water withdrawal, and contaminants;
- <u>Behavioral disturbance</u> from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during Project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats;

- Attraction to Project facilities (e.g., herbivores to areas of early snowmelt in spring, predators and scavengers to artificial food sources); caribou who may be attracted to pads and roads for insect relief;
- Increased mortality in prey populations if predators increase as a result of the availability of anthropogenic foods;
- Injury and mortality of wildlife from vehicle collisions and from contact with or ingestion of contaminants; and
- Long-term habitat loss because of accidental spills.

To the extent possible, the discussion of effects that follows is organized by phase of development (drilling, construction, operations) and by Project activity/components that are likely to affect terrestrial mammals.

4.2.6.1 Drilling

Habitat Loss and Alteration

Gravel Placement and Ice Roads/Pads

No gravel placement is planned for the Drilling phase of the Project. The effects of gravel placement would occur during the Construction phase and the effects of habitat loss are described in that section. During the Drilling phase, access to the Project site would be by a nearshore ice road, and onshore ice roads and support pads would be used. Although some damage to habitats results from the use of onshore ice roads, the long-term effects are considerably less than those associated with gravel roads and pads. Small amounts of terrestrial habitat would be temporarily affected during the Drilling phase by delayed snowmelt and compaction in the areas underlying onshore ice roads and pads, not including snow dumps and persistent drifts around drill sites and storage pads.

The effects of delayed snowmelt would be confined primarily to the first and second growing seasons following cessation of use, whereas the effects of compaction may persist longer. In most years, ice roads and associated snow drifts would not melt until after the onset of nesting (late May–early June) for most species of birds, reducing the local availability of nest sites and thus food for mammalian predators. Compaction of the standing dead vegetation remaining from previous growing seasons would reduce or eliminate concealing cover used by small mammals. Disruption and compaction of snow cover under ice roads and pads would eliminate the subnivean spaces used in winter by small mammals. These temporary losses of habitat are most likely to affect small mammal species with small home ranges, but some animals displaced by this temporary habitat loss may relocate to unaffected habitats nearby. The effects of ice roads and pads on mammals and their habitats would be restricted to the periods during use and up to two years after use.

TABLE 4-22: SUMMARY OF THE LIKELY EFFECTS* ON TERRESTRIAL MAMMALS

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling					
Gravel Mining And Placement And Ice Roads/Pads	Low (few onshore facilities during drilling)	Local	Temporary	All species, primarily of concern for common species (small mammals)	Minor
Snow Dumps And Snow Drifts	Low	Local	Temporary	All species	Minor
Noise And Traffic Effects	Medium (moderate traffic rates during drilling, only during winter, primarily on nearshore ice road)	Local to Regional	Temporary	Primarily common species (arctic fox; few terrestrial mammals present during winter)	Minor
Attraction And Human/Animal Interaction	Low	Local	Temporary	Primarily common species (arctic fox)	Minor
Increased Predation	Low	Local to Regional	Temporary	Primarily common species (arctic fox)	Minor
Spills, Leaks, And Contamination	Low to High	Local to Regional	Long-term	All species	Minor to major (effects would vary depending on the nature of the spill)
Construction					
Gravel Mining And Placement	High (physical destruction of habitat)	Local	Permanent	All species (habitat loss)	Minor
Ice Roads And Ice Pads	Low	Local	Temporary	Primarily common species (small mammals)	Minor
Snow Dumps And Snow Drifts	Low	Local	Long-term	All species	Minor
Obstruction Of Flow	Low	Local	Temporary to Long-term	All species	Minor
Dust Fallout	Low	Local	Temporary to Long-term	All species	Minor
Noise And Traffic	High (high traffic rates	Local to National/International	Temporary	All species, primarily of concern	Minor to moderate

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
	during construction, on both nearshore winter ice road and onshore year-round)			for unique caribou herds	
Attraction And Human/Animal Interaction	Low	Local	Temporary	Common and important species (foxes, grizzly bear, caribou)	Minor to moderate
Increased Predation	Low	Local to Regional	Temporary	Common and important species (foxes, grizzly bear)	Minor
Spills, Leaks, And Contamination	Low to High	Local to Regional	Long-term	All species	Minor to major (effects would vary depending on the nature of the spill)
Operation					
Snow Dumps And Snow Drifts	Low	Local	Long-term	Primarily common species (small mammals)	Minor
Obstruction Of Flow	Low	Local	Temporary to long-term	All species	Minor
Dust Fallout	Low	Local	Long-term	All species	Minor
Thermokarst	Low	Local	Long-term to Permanent	All species (habitat alteration/loss)	Minor
Noise And Traffic	Low to Medium (low traffic rates during operation, occasionally also on nearshore winter ice roads)	Local	Long-term	All species, primarily of concern for unique caribou herds	Minor to moderate
Attraction And Human/Animal Interaction	Low	Local	Long-term	Common and important species (foxes, grizzly bear, caribou)	Minor to moderate
Increased Predation	Low	Local to Regional	Long-term	Common and important species	Minor

PROJECT PHASE Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
				(foxes, grizzly bear)	
Spills, Leaks, And Contamination	Low to High	Local	Long-term	All species	Minor to moderate (effects would vary depending on the nature of the spill)

Notes:
1 Intensity (severity) = Low, Medium, High
2 Scope / Magnitude (geographic) = Local, Regional, National/International (e.g., for migratory species)
3 Duration = Temporary, Long-term, Permanent
4 Context = Common, Important (grizzly bear, caribou), Unique (Porcupine caribou herd, Central Arctic caribou herd)
5 Overall = None, Minor, Moderate, Major. The effects assessed for each project activity/component were: (1) long-term habitat loss from gravel extraction and stockpiling at the mine site and gravel placement for the construction of three gravel pads, the airstrip, and the interconnecting road system; (2) temporary habitat loss from soil compaction, disturbance of vegetation, and persistent accumulation of snow and ice following the use of temporary ice roads and work pads; (3) changes in the use of habitats altered by dust fallout, gravel spray from snow removal, persistent snow drifts, thermokarst, water flow alteration and impoundments, water withdrawal, and contaminants; (4) behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats; (5) attraction to project facilities (e.g., herbivores to areas of early snowmelt in spring, predators and scavengers to artificial food sources); (6) increased mortality from predator populations if predators increase as a result of the availability of anthropogenic foods; (7) injury and mortality of wildlife from vehicle collisions and from contact with or ingestion of contaminants; and (8) long-term habitat loss due to accidental spills.
* This table present anticipated effects of the Project and does not include major spills or well blowouts.

The magnitude of effects of onshore ice roads and pads varies, depending on the volume of ice in the underlying sediments (Adam and Hernandez 1977), the vegetation type (Racine 1977; Walker et al. 1987; Emers et al. 1995), and the duration of use (Buttrick 1973; Adam and Hernandez 1977). Although overlapping use of the same ice-road route in successive years indicated minor effects on thaw depth, damage to tussocks, and ground-cover percentage, the effects of ice roads may increase with the duration of use among years (Yokel et al. 2007). Although most research on the effects of winter travel on tundra habitats has focused on seismic trails rather than snow and ice roads (Felix and Raynolds 1989; Emers et al. 1995), both methods can produce similar effects (Adam and Hernandez 1977; Johnson and Collins 1980): torn and crushed sedge tussocks, broken and abraded willows, and mortality of crushed mosses and lichens (Walker et al. 1987). Some individual plants may be killed or small areas damaged, but recovery usually occurs within several years. Long-term, local damage can result if plant cover is removed (ripped or scraped) or the soil surface is disrupted.

Compaction and vegetation disruption by onshore ice roads and work pads have greater effects in dry and moist habitats than in wet habitats. The habitats most affected by onshore snow and ice roads are moist tussock tundra, riparian shrub, and moist sedge–shrub meadows (Felix and Raynolds 1989; Emers et al. 1995). Shrub habitats are important for small mammals such as collared lemmings and voles and for large mammals such as moose and muskoxen; changes in plant species composition in these habitats may cause localized degradation of habitat quality for these mammals, similar to the winter road effects on small mammals reported by Douglass (1977). The net effect of temporary habitat losses likely would be minor because of the relatively small proportion of the Project area affected, and mammal populations would not be likely to decrease as a result of these effects.

Snow Dumps and Snow Drifts

Similar to ice roads, the snow dumps and snow drifts associated with ice pads, ice roads, and snow fences during the Drilling phase would cause temporary habitat loss or alteration for terrestrial mammals. Persistent snow in spring would likely persist into the bird nesting season, reducing nest densities in affected areas and thus reducing food availability for mammalian predators. If ice pads and roads occur in the same locations in successive years, snow dumps and drifts may occur annually, eventually leading to alteration of vegetation and habitat loss or alteration for terrestrial mammals. The overall effects of snow dumps and snow drifts on terrestrial mammals would be minor, because of the small area affected.

Spills, Leaks, and Contamination

Accidental spills are an inherent risk associated with oil extraction in all phases of development. The major contaminants associated with oil field development include crude oil, diesel fuel, seawater, brine, and glycol (Jorgenson and Joyce 1994). In addition, disposed drill cuttings also are potential contaminants, depending on the chemical composition of the material and the method of disposal. Accidental spills during the Drilling phase may also include vehicle fuels, lubricants, or other contaminants. The most common reported spills in oil fields are small crude oil and salt water spills that affect small areas of tundra.

Because of the small terrestrial footprint of the Drilling phase of the Project, accidental spills would be limited to the nearshore ice road corridor and the onshore ice roads and drill sites, which are located on existing gravel pads. Spills of hydrocarbons and other fluids degrade wildlife habitats by physically covering vegetation, thawing permafrost, and exerting toxic effects on plants and prey species. Small spills occurring during the Drilling phase of the Project are not expected to result in population-level effects attributable to habitat alteration.

Disturbance Effects

Noise and Traffic Effects

The effects of noise and traffic on terrestrial mammals are discussed in detail below under the Construction phase of the Project, when these effects would peak. During the Drilling phase, behavioral disturbance caused by noise and traffic would occur during mid– to late winter along the coastal route of the nearshore ice road, near the drilling pads, and near aircraft landing areas. Terrestrial mammals potentially affected would include arctic foxes and possibly small numbers of overwintering caribou or muskoxen. Because of the small numbers of terrestrial mammals residing in coastal habitats during winter, the effects of noise and traffic are expected to be minor.

Road kills of terrestrial mammals during the Drilling phase may occur anywhere along the ice roads built to support drilling. Because of the small numbers of terrestrial mammals in coastal habitats during winter, the effects of such injury and mortality are expected to be minor and to affect primarily arctic foxes or small numbers of overwintering caribou or muskoxen.

Population/Mortality/Injury Effects

Attraction and Human-Animal Interaction

Human-animal interactions would occur during all phase of the Project, but are discussed in more detail under Construction, when the potential for human-animal interactions is greater. Because activities during the Drilling phase are restricted to mid–late winter, human-animal interactions during the Drilling phase would occur primarily with arctic foxes and polar bears (discussed in Section 4.2.7, Threatened and Endangered Species). The effects of human-animal interactions on terrestrial mammals are expected to be minor during the Drilling phase of the Project.

Increased Predation

Populations of foxes, grizzly bears, gulls, and ravens have increased with the development of the North Slope oil fields (Burgess 2000; Shideler and Hechtel 2000) and these predator/scavengers would be attracted to developed sites during all phases of the Project (gulls seasonally, all others year-round). Because activities during the Drilling phase are restricted to mid- to late winter, local increases in abundance would occur primarily for arctic foxes and ravens and are expected to be temporary, not persisting into the summer months when no drilling activities are scheduled. During the Drilling phase, the effect on arctic foxes is expected to be minor, as is the effect on prey populations of terrestrial mammals and birds. A more thorough discussion of increased predator populations is presented under Construction, when greater effects on foxes, bears, and prey species are expected, and in Section 4.2.4 Birds.

Spills, Leaks, and Contamination

Accidental spills are an inherent risk associated with oil extraction in all phases of development. The major contaminants associated with oil field development include crude oil, diesel fuel, seawater, brine, and glycol (Jorgenson and Joyce 1994). In addition, disposed drill cuttings also are potential contaminants, depending on the chemical composition of the material and the method of disposal. Accidental spills during the Drilling phase may also include vehicle fuels, lubricants, or other contaminants. The most common reported spills in oil fields are small crude oil and salt water spills that affect small areas of tundra.

Contaminant spills have the potential to result in injury and mortality of terrestrial mammals. Exposure to and ingestion of contaminants (including minor incidents of fouling and oiling) in the North Slope oil fields occasionally results in injury and mortality to small numbers of animals (Amstrup et al. 1989; ABR 2007). Contaminants can negatively affect mammals through dermal contact, dermal absorption, ingestion, and inhalation. Dermal contact can change the ability of hair to insulate or to shed water.

Because of the small terrestrial footprint of the Drilling phase of the Project, accidental spills would be limited to the nearshore ice-road corridor and the onshore drilling sites, which are located on existing gravel pads. Because the Drilling phase is restricted entirely to mid- to late winter, few terrestrial mammals would be affected by an accidental spill, primarily arctic foxes and resident small mammal species. The most likely oil field spills during the Drilling phase (small volume spills of fuels and fluids necessary for vehicle/machinery operations) are unlikely to have population-level effects on terrestrial mammals attributable to habitat alteration. The risk of large spills are considered in detail separately in Section 4-4. Larger spills could result in larger habitat-alteration effects.

4.2.6.2 Construction

<u>Habitat Loss and Alteration</u>

Gravel Mining and Placement

Gravel mine development and pad and road construction would occur during winter. Mine development and gravel placement would cause long-term alteration of 272 acres (1.10 square kilometers) of terrestrial habitats used by mammals, excluding waterbodies and existing gravel pads (Table 4-17).

Gravel placement for the proposed facilities would result in the permanent loss of 202 acres (0.8 square kilometers) of terrestrial habitat underlying all gravel pads and roads. The amount of habitat lost to gravel mine excavation and stockpiles would encompass another 69.9 acres (0.3 square kilometers) of terrestrial habitat (i.e., excluding water). In addition to gravel placement, 0.7 acres (2,833 square meters) of habitat would be lost as a result of the installation of pipeline

VSMs, airstrip trenching, emergency boat launch, and NavAid VSMs. Total long-term loss of terrestrial habitats associated with the Project is approximately 277 acres (1.10 square miles).

Gravel fill has a major effect on wildlife habitats in the Arctic because the disturbance is long-term and vegetation recovery is difficult (Johnson 1987; Walker et al. 1987; Jorgenson and Cater 1990). Gravel pads and roads must be thick (up to 6 feet [2 meters]) to prevent thawing of permafrost and subsidence of the ground surface beneath them. Consequently, the gravel is isolated from the hydrologic regime of the surrounding tundra, making the establishment of plants difficult without soil amendments because of the low nutrient content and limited water-holding capacity of the gravel (Jorgenson and Cater 1990; Jorgenson et al. 1990). These changes effectively eliminate areas covered by gravel as productive breeding and foraging habitats for wildlife; this loss is considered long-term. Some of the gravel fill areas, such as roads, will provide additional insect-relief habitat for caribou. Over periods of years or decades, restoration may improve habitat conditions for some terrestrial mammals, particularly if gravel cover is removed, but the habitats would be substantially altered.

Vegetation types that would be most affected by gravel placement during the Construction phase are wet sedge/moist sedge, dwarf shrub tundra complex; moist sedge, dwarf shrub tundra; and moist sedge, dwarf shrub/wet graminoid complex, together comprising 73.1 percent 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 Project area. Riparian habitats that are used particularly by moose, muskoxen, and grizzly bears comprise less than 0.2 percent of the Project footprint (see Table 4-17).

Dry upland sites that are important to ground squirrels and denning arctic foxes comprise 3.4 percent of the Project footprint (see Table 4-17). In general, for all vegetation types affected, the amount of habitat loss would be small relative to abundance in the Project area.

Gravel mining and placement and other ground disturbance would result in the loss of 277 acres (1.10 square kilometers) of potential caribou foraging habitat, constituting approximately 0.02 percent of the 1.6 million acres (6,493 square kilometers; Wolfe 2000) of the Central Arctic Herd (CAH) calving range east of the Sagavanirktok River.

All or most of the 277-acre (1.10 square kilometer) terrestrial footprint of the Project comprises small mammal habitat. Because no estimates of the population densities of small mammals in the affected area are available, the population effects cannot be quantified. Some small mammals probably would be killed during construction and most others would be displaced to adjacent habitats.

In summary, in view of the relatively small acreage covered by gravel, the small percentage of each habitat type lost, and the ability of mammal species to relocate to adjacent undisturbed habitats, the direct effects of gravel placement on mammal populations from the Project would be minor.

Ice Roads and Ice Pads

In addition to the nearshore ice road, onshore ice roads and pads would be used during the Construction phase, primarily to support pipeline construction. As discussed above for the Drilling phase, the effects of onshore ice roads on vegetation would 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 and pads during winter pipeline construction is expected to have minor effects on terrestrial mammals because of the small area affected.

Snow Dumps and Snow Drifts

As during the other phases, snow dumps and snow drifts adjacent to pads or roads during the Construction phase would displace small mammals and have localized effects on vegetation because of delayed snow melting. Areas affected by snow dumps and snow drifts associated with the Project are expected to be minor because of the small footprint of the Project.

Deep snow drifts often accumulate in older portions of the North Slope oil fields where elevated pipelines are located close to road berms, and shallow drifting may occur adjacent to elevated pipelines away from roads, as well (depending on orientation). Snow depth under pipelines is substantially lower where they are separated from roads and is highly dependent on landform and pipeline orientation. A study of snow accumulation under and adjacent to elevated pipelines, conducted on the western North Slope in late winter 2001 (Pullman and Lawhead 2002), found that snow depths under east–west-oriented pipelines (i.e., the orientation of most of the pipelines proposed for the Project) were significantly deeper than adjacent background levels in lake-basin habitats, but significantly shallower in terrace habitats. East–west-oriented pipelines also tended to accumulate drifts within 65 feet (20 meters) of the pipeline (although depths were shallow). The presence of an ice road immediately adjacent to an elevated pipeline resulted in substantial drifting and reduced ground clearance under the pipeline (Pullman and Lawhead 2002), potentially posing an obstruction for caribou movements under the pipe. Judging from the recent distribution of calving caribou in the area between Bullen Point and the Staines River, and the proximity of the applicant's proposed facilities to the sea coast, snow drifting under portions of the proposed pipeline would pose little interference with movements onto and within the calving grounds, even in years with late snow melt. In addition, the recommended separation distance of 300–500 feet (91–52 meters) or more between pipelines and roads (Curatolo and Reges 1986; Cronin et al. 1994) would reduce snow drifting and facilitate crossing success. The potential for snow drifts to interfere with caribou crossings under elevated pipelines would be highest in lake-basin habitats in years of late snow melt, when caribou tend to calve farther inland. In such years, rates of crossing might decrease in lake-basin habitats and increase in adjacent areas with greater pipeline clearance. In years of early snowmelt, no drifts would persist in the calving season. The proximity of pipelines to the coast (which is the fringe of calving habitat) and the lack of winter activity of caribou in the Project area would result in minor effects on caribou crossings of pipelines when snow cover is present.

Obstruction of Flow

Impoundments occur when surface drainage is impeded by roads and pads. Impoundments can be temporary, disappearing by mid-June, or persist through summer. Depending on the duration of seasonal impoundments, the resulting habitat alterations can range from minor and temporary to major and long-term. Water impounded by gravel roads and pads can displace resident small mammals and inhibit grazing by large herbivores. Temporary impoundments preclude nesting, but they also attract some birds (Troy 1986, 2000; Kertell and Howard 1992; Kertell 1993, 1994; Walker et al. 1987). Terrestrial mammalian predators would be affected negatively by reduced nest densities. If birds are attracted to temporary impoundments, terrestrial mammalian predators may benefit, although birds are safe from mammalian predators in open water habitats.

For the Project, culverts would be placed during construction to minimize the formation of large, long-term impoundments adjacent to roads and pads. It is likely that small temporary impoundments still would occur during spring, potentially affecting some bird species (shorebirds and waterfowl) and thus indirectly mammalian predators. Additional culverts or other drainage structures could be installed after construction to drain any long-term impoundments that might form following gravel placement. Therefore, the potential effects because of the formation of impoundments associated with gravel roads and pads are expected to be minor for mammals.

Dust Fallout

Dust fallout adjacent to gravel structures causes physical changes in affected habitats. The primary effects of dust fallout include advanced snowmelt (up to two weeks early) because of increased albedo, increased depth of seasonal thaw (to 20 inches [0.5 meter] in ice-rich polygons), thermokarst, increased soil pH, reduced photosynthetic capability of plants, decreases in acidophilus mosses (particularly *Sphagnum*) and some lichens (*Cladina* and *Peltigera*) and increases in other mosses, decreases in some prostrate shrubs (*Dryas* and *Ledum*), and barren patches of ground (Spatt 1978; Everett 1980; Spatt and Miller 1981; Werbe 1980; Klinger et al. 1983; Walker et al. 1985; Walker and Everett 1987). Cotton sedges such as *Eriophorum* are more tolerant of dust exposure, perhaps because they occur in wetter areas and appear to be more adapted to disturbed areas than other species (Everett 1980).

Advanced snowmelt in dusted areas often contributes to impoundment of runoff and results in early “green-up” of plant species (e.g., *Eriophorum vaginatum*) (Makihara 1983; Walker and Everett 1987). The magnitude of dust effects depends on traffic intensity and the distance from the source; the effects are most pronounced within 35 feet (10 meters) of the source (Everett 1980; Walker and Everett 1987).

Advanced snowmelt because of dust fallout can have both positive and negative effects on terrestrial mammals. Exposure of vegetation and early plant growth in “dust shadows” along gravel roads attracts caribou as well as ptarmigan and waterfowl (Walker and Everett 1987; Lawhead and Cameron 1988; Murphy and Anderson 1993; Lawhead and Johnson 2000; Lawhead et al. 2004). Although these animals gain early access to nutritious forage, their exposure to traffic-related disturbance and risk of vehicle strikes increases simultaneously.

The effects of dust fallout on terrestrial mammals would occur during all phases of the Project, but would be greatest during the Construction phase, when traffic rates would be highest. Dust fallout would cause early snowmelt adjacent to the road system, airstrip, and gravel pads in the Project area, which would attract some wildlife species in spring. Although vegetation is available earlier in dust shadows than elsewhere, thereby providing early foraging opportunities for caribou and other herbivores, this potential benefit may be offset by the higher exposure to human disturbance adjacent to occupied facilities and heavily trafficked roads. Dust fallout is expected to have minor effects on terrestrial mammals because of the small areas affected.

Disturbance Effects

Noise and Traffic

Behavioral disturbance of terrestrial mammals would occur during all three phases of the Project. Vehicle and aircraft traffic rates would be highest and the number of on-site resident employees would peak during Construction. Potential direct effects of behavioral disturbance include immediate responses of affected animals (including energetic or other costs associated with startle or flight responses), indirect loss of habitat caused by avoidance, and attraction of some species to areas of human activity (particularly predator/scavengers). For some species, indirect effects of disturbance may include long-term reduction in wildlife use in areas experiencing constant disturbance. Most terrestrial mammal species may habituate readily to low-level constant noise, although maternal caribou may be a notable exception. Maternal caribou generally avoid habitats within 1.25–2.5 miles (2–4 kilometers) of active roads and pads during and immediately after the calving season in June, as described below.

During winter months, Construction phase activities would include ice-road construction; mining, storage, and placement of gravel for roads, pads, and airstrip; development drilling; and pipeline installation. Summer Construction phase activities would include gravel mining and placement and maintenance of winter-mined gravel roads and pads during their first thaw season. Few caribou, muskoxen, grizzly bears, moose, or wolves are likely to be present in the Project area during the winter, but larger numbers of terrestrial mammals would be present during summer months, including potentially large numbers of caribou, as well as small numbers of grizzly bear and occasionally muskoxen. The effects of noise and traffic are expected to be moderate for caribou and minor for other terrestrial mammals, as is described in more detail in the following sections.

Caribou: Disturbance by traffic, structures, and human activities causes a variety of effects on caribou behavior and movements (see summaries by Shideler 1986; Cronin et al. 1994; Murphy and Lawhead 2000; Lawhead et al. 2006). In general order of decreasing concern, such effects include displacement of maternal caribou during calving and early lactation; deflections and delays in caribou movements across pipelines and roads during the insect season; increased energy expenditure and stress caused by reactions to disturbance; attraction of caribou, potentially in large numbers, to gravel roads and pads during insect harassment; and accidental injury and mortality from vehicle strikes.

The most important effect of the Project on terrestrial mammals would be disturbance and displacement of maternal caribou near Project facilities and Project activities during the calving season and early lactation. The CAH has shifted its areas of concentrated calving several times over the last 20 years, with the most recent shift to an inland area southwest of the Project site (Section 3.2.6). The Porcupine Herd (PH) does not calve in the Project area (Section 3.2.6).

Research in the Kuparuk and Milne Point fields has demonstrated that female caribou with calves up to three weeks old tend to avoid areas within at least 1,650–3,300 feet (503–1,006 meters) (Johnson and Lawhead 1989; Cronin et al. 1994), and as far as 1.25–2.5 miles (2–4 kilometers) from active pads and roads (Dau and Cameron 1986; Lawhead 1988; Cameron et al. 1992; Lawhead et al. 2004). This displacement effect has been confirmed statistically, but it does not cause complete abandonment of the calving grounds within these distance buffers, and some maternal females, which are presumably less susceptible to human disturbance, may occur within these distances. The stimulus for this effect appears to be human activity (eliciting a predator-avoidance response) rather than the presence of infrastructure alone, and the effect occurs along roads experiencing even relatively low levels of traffic (Dau and Cameron 1986; Lawhead 1988; Lawhead et al. 2004). Thus, except perhaps for a small proportion of maternal females, the available evidence indicates that maternal caribou with young calves do not habituate to road traffic (as would be expected for an antipredator response). This displacement effect persists from the time calves are born (late May–mid-June) for up to three weeks or until mosquitoes begin to emerge (mid–late June, depending on the location and year) (Lawhead et al. 2004; Haskell et al. 2006).

Therefore, the Project is likely to cause localized displacement of most maternal caribou from the area surrounding the in-field road and drill sites during and immediately after the calving season, during both the Construction and Operations phases of the Project. Applying distance buffers of 1.25–2.5 miles (2.0–4.0 kilometers) for avoidance of the Project facilities (as described above), the estimated area of reduced density of maternal caribou during and immediately after the calving season would range from an estimated 17,443 acres (70.6 square kilometers) to as much as 30,577 acres (123.7 square kilometers). The avoidance zones surrounding the Project facilities are located in areas that experienced fairly low caribou density (i.e., the 75–90 percent utilization contours delineated using fixed-kernel analysis) during CAH calving in 1990–2001 (Figure 3-19). However, these affected areas are within the concentrated calving area formerly used by the eastern segment of the CAH in the early 1980s (Lawhead and Curatolo 1984; Wolfe 2000). With the exception of 2002, concentrated calving has not been recorded in the vicinity of the Project infrastructure since the mid-1980s (Wolfe 2000; Jensen et al. 2003; Arthur and Del Vecchio 2007). Because no calving by the PH has been recorded in the Project area, the applicant's Project would not be expected to affect calving by that herd, although the northwestern extreme edge of the calving range of the PH is within 2.5 miles (4.0 kilometers) of the eastern end of the Project facilities (Figure 3-17). Localized displacement of maternal caribou during and immediately after calving is expected to have moderate effects on caribou habitat use, but those effects are unlikely to result in population-level effects, because of the relatively low level of current use of the affected area by calving females and the availability of comparable or higher-density habitats southwest of the Project infrastructure.

During the insect season, harassment by insects overwhelms the avoidance response seen during calving, 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 (Curatolo and Murphy 1986; Murphy and Curatolo 1987; Murphy and Lawhead 2000; Noel and

Demarchi 2002). The location of the proposed facilities near and along the Beaufort Sea coast would result in a high frequency of caribou encounters and pipeline–road crossings during the insect season in most years, as caribou aggregate and move to the coast from inland areas (Figure 3-21). The location of the three gravel pads immediately adjacent to the coast makes it highly likely that large groups of insect-harassed caribou would encounter them during the most severe periods of insect harassment, when they move to and along the coast and even enter the ocean to stand in shallow water or occupy spits and islands. The continuing growth and relatively large size of the CAH make it likely that several tens of thousands of caribou could encounter Project infrastructure during the insect season. This season is also the time when large numbers of PH animals could encounter the Project facilities as well.

The clearest behavioral effect of road traffic during insect season is reduced crossing success when caribou groups attempt to cross pipelines that are within 300 feet (91 meters) of roads with high traffic rates (15 or more vehicles per hour) (Curatolo and Murphy 1986; Curatolo and Reges 1986; 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). Increased energetic demands on individual lactating females provide the most likely theoretical pathway for the combination of human disturbance and insect harassment to translate to a population-level effect, through potential decreases in the probability of conception and thus decreases in reproductive success in subsequent years (Cameron et al. 1993; Murphy et al. 2000; Cameron et al. 2005). Although empirical verification of this theoretical pathway has not been demonstrated unequivocally (Murphy and Lawhead 2000), Griffith et al. (2002) assumed it has slowed the growth of the CAH and it was invoked as the commonly accepted cause for reduced reproductive success by radio-collared CAH females in years following above-average levels of insect harassment during 1987–2001 (NRC 2003). Currently, there is no consensus among caribou researchers regarding the extent to which oil field development in the central North Slope may have affected the population dynamics of the CAH. Nevertheless, reduced road-crossing success and delayed and deflected movements during the insect season are expected to have moderate effects on caribou movements and energy budgets, primarily for CAH animals, but also potentially for some PH animals in years when they move into the Project vicinity.

In addition to avoidance and displacement, the reactions of caribou to disturbing stimuli can increase energy expenditure. The costs associated with reactions to disturbance would occur during all seasons; although, as described above, such costs may be increased by insect harassment, deflected movements, and other effects. Evaluation of the instantaneous reactions of CAH caribou to disturbing stimuli near oil field infrastructure has demonstrated that the most common disturbance events (resulting in increased locomotion) are caused by vehicles when caribou are within 325–650 feet (100–200 meters) of roads (Curatolo and Murphy 1986; Lawhead et al. 1993; Cronin et al. 1994). The strongest reactions (in terms of reaction distance and distance moved) occur in response to humans on foot. Aircraft disturbance of caribou was of greater concern by researchers early (1970s) in the period of oil field development than it is today, as most CAH caribou appear to have habituated to nonharassing overflights by small aircraft (possibly because of the high frequency of occurrence of small aircraft in their summer range). In the absence of other associated effects (such as insect harassment and deflected movements), the instantaneous reactions of caribou to human-related disturbances are expected to have minor energetic effects on caribou.

To reduce the potential for oil field effects on insect-season movements, research since the 1980s focused on infrastructure designs and management practices to facilitate caribou crossing success, and that research has resulted in the development of standard mitigative measures (Cronin et al. 1994; Murphy and Lawhead 2000; Lawhead et al. 2006). A principal mitigative measure is to elevate pipelines to the state-required minimum height of 5 feet (1.5 meters) above the ground surface (measured at the bottom of the pipe or vibration dampeners, whichever is lower), which results in substantial stretches of pipe higher than 5 feet (1.5 meters) as it crosses irregularities in the tundra surface. A pipeline constructed to the standard minimum height of 5 feet (1.5 meters) above the ground surface does not impede caribou movements during snow-free seasons as long as a road with a high traffic rate is not located nearby (Curatolo and Murphy 1986; Lawhead et al. 1993; Cronin et al. 1994; Lawhead et al. 2006). Pipelines for the Project would be constructed to a minimum height of 7 feet (2.1 meters) above the ground surface to provide extra assurance of caribou crossing success; the 7-foot (2.1-meter) height has been recommended in areas where caribou may occur in winter (Lawhead et al. 2006).

Another standard mitigative measure is to assure adequate separation of elevated pipelines from adjacent gravel roads. A distance of 300 feet (91 meters) was identified as the minimum separation necessary to ensure that crossing success was not reduced (Curatolo and Reges 1986), but a greater distance (400–500 feet [122–152 meters]) has been recommended to provide extra assurance of mitigation (Cronin et al. 1994). Of the 27.4 miles (44.1 kilometers) of pipeline ROW associated with the Project, 26.4 miles (42.5 kilometers) (96 percent) would be located more than 300 feet (92 meters) and 25.8 miles (41.5 meters) (94 percent) would be located more than 500 feet (152 meters) from gravel roads. Even with adequate mitigation (pipe height and road separations), some deflections and delays in movements of caribou seeking to cross pipeline-road corridors would occur; however, primarily during the insect season and mainly during the Construction phase, when Project traffic rates would peak (traffic forecasts have not yet been developed for the Project). Those effects would abate during the Operations phase, when traffic levels would decline substantially.

In contrast to mosquito-harassed caribou, which typically move around gravel pads (Johnson and Lawhead 1989), caribou harassed by oestrid flies often stop on or are attracted to them, seeking relief on elevated and shaded sites (Roby 1978; Johnson and Lawhead 1989; Pollard et al. 1996; Noel et al. 1998). The presence of elevated gravel pads and roads during simultaneous harassment by mosquitoes and oestrid flies can cause a mixed response by harassed caribou that often results in large groups occupying pads and roads for extended periods of time, usually in mid- to late July (Lawhead and Flint 1993; Lawhead et al. 1993). At such times, it is likely that groups numbering up to several thousand caribou, and perhaps even more in view of the continuing growth of the CAH, may move onto any or all of the proposed gravel pads, roads, and airstrip, remaining until insect harassment subsides and they move off the pad(s), and substantially slowing vehicle traffic and human activities on affected roads and pads. The presence of elevated gravel pads and roads and shaded or sheltered areas (including elevated pipelines, VSMs, buildings, and even parked vehicles) would provide relief habitat for some caribou seeking to escape oestrid flies. On the other hand, the attraction of caribou to such sites increases contact between humans and caribou, increasing disturbance rates and potentially increasing the potential for injury by vehicles or contaminants. Overall, despite the potentially large numbers involved, the attraction of caribou to gravel pads and roads is expected to have minor effects on caribou.

Vehicles associated with the Project are likely to strike caribou occasionally, causing injury and mortality. Such accidents are likely to occur during all three phases of the Project, but the risk of vehicle strikes would be greatest during summer, when large numbers of insect-harassed caribou are present, and during the Construction phase, when traffic rates would be highest. The scheduling of most construction activity during winter months reduces the potential for vehicle strikes of caribou. Although the incidence of vehicle-caused mortality is poorly documented for the Prudhoe Bay and Kuparuk oil fields, the number of animals injured or killed by vehicles is thought to be low. As is practiced at other airstrips in the oil field region, hazing of fly-harassed caribou that are attracted to the elevated gravel airstrip would be necessary to minimize the risk of an aircraft collision.

As was described above, 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. The risk of vehicles striking caribou would be greatest from mid-July to mid-August, when caribou are attracted to pipelines, roads, and pads seeking relief from fly harassment; at such times, caribou tend to be less alert around vehicles than at other times of the year (Roby 1978; 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. Death and injury of caribou from vehicle strikes is anticipated to have minor effects on caribou.

In summary, all evidence indicates that large numbers of caribou will very likely encounter the Project annually during post-calving and insect season movements. The effects related to noise and traffic disturbance from the Project on caribou during the Construction phase (and other Project phases) would include (1) moderate effects on the distribution of maternal caribou during and after calving, (2) moderate effects on the distribution and movements of all caribou during the insect season (including reduced pipeline-road crossing success, deflections of movements, and delays in crossing), (3) minor effects on energy expenditure caused by instantaneous behavioral reactions to disturbance, (4) minor effects on distribution during insect harassment (including attraction to roads and pads), and (5) minor effects associated with accidental mortality of caribou from vehicle strikes.

Other Mammals: The Project may cause behavioral disturbance of other large mammals, such as muskoxen and grizzly bears. Relatively little is known about the responses of muskoxen to oil field facilities and activities, but the species is known to be sensitive to disturbance by aircraft and snowmachine (Miller and Gunn 1979; Clough et al. 1987). It is reasonable to conclude that behavioral responses of muskoxen to oil field structures would be similar to those of caribou.

Recent observations in the oil fields (ABR 2007) indicate that muskoxen cross elevated pipelines, with and without adjacent roads, but the behavioral effect of traffic on muskoxen has not been investigated. Muskoxen moving between the Canning and Shaviovik river drainages would be most likely to encounter the proposed development facilities, but the currently rare occurrence of muskoxen in the Project area makes such encounters unlikely; the probability would increase in the future if the regional muskox population increases or the distribution of the species changes again. Therefore, the effects likely would be minor unless the regional population of muskoxen increases significantly. In the event that the muskox population does increase, it is reasonable to conclude that the behavioral response of muskoxen to oil field structures would be similar to those of caribou, with minor effects on energy status, distribution, movements, and productivity.

Disturbance of bears during winter denning (Reynolds et al. 1986; Clough et al. 1987; Amstrup 1993, 2000; Linnell et al. 2000) has the potential to displace bears from their dens, risking mortality of cubs or poorly nourished adults. Grizzly bears are thought to respond to disturbance of dens in a way similar to polar bears, which have been known to abandon dens as a result of disturbance (Clough et al. 1987). Amstrup (1993, 2000) concluded, however, that many bears exposed to human activities were not likely to be affected in ways that reduced production of young. Use of the project vicinity by grizzly bears is relatively low and the amount of suitable denning habitat in the Project area is limited, suggesting that the number of bears denning near Project facilities or activity areas would be low, thereby reducing the risk of den disturbance to a minor level. Efforts would be taken to avoid disturbing denning bears during the Drilling and Construction phases. Ongoing consultation with agency biologists monitoring satellite- and radio-collared bears in the region would help to provide accurate location information to avoid some dens. The effect of disturbance by noise and traffic from the Project is anticipated to be minor for grizzly bears.

Vehicle traffic associated with the Project is likely to strike foxes or other terrestrial mammals occasionally, causing injury and mortality; the risk of aircraft collision is very low. Such accidents are likely to occur during all three phases of the Project, but the risks of vehicle strikes would be greatest during summer, when larger numbers of terrestrial mammals are present, and during the Construction phase, when traffic rates would be highest. Arctic foxes are present year-round and subject to vehicle strikes during all seasons. Arctic foxes also inhabit sea-ice habitats during winter months and may be more exposed than other terrestrial mammals to risk of vehicle strikes on the nearshore ice road in both the Drilling and Construction phases of the Project. Nonetheless, the scheduling of most construction activity during winter months reduces the potential for vehicle strikes of mammals during that phase, because of the low numbers of mammals present in the Project area in that season. Although the incidence of 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.

The risk of vehicle strikes in the existing North Slope oil fields can be minimized through suitable environmental and safety training of personnel and by mandating that all drivers yield the right-of-way to wildlife. By applying similar management practices at the Project site, the risk of injury to mammals from collisions would be minor and unlikely to cause negative population-level effects.

Freshwater Pipeline

Construction of the freshwater pipeline to the Central Pad, initially from the C-1 site and later from the reservoir created by the gravel mine, may inhibit free movement of some mammals. Current plans call for an insulated pipeline approximately 8 inches (20 centimeters) in diameter resting on sleepers on the tundra, yielding an overall height of approximately 16 inches (41 centimeters) above grade, suggesting an average of approximately 8 inches (20 centimeters) of clearance between the bottom of the pipe and the ground. This pipeline will provide fresh water to the Central Pad camp during the Construction and Operations phases. The route of the freshwater pipeline has not been determined, but will likely parallel proposed gravel access routes between the reservoirs and the Central Pad almost due north, a distance of 3–4 miles (4.8–6.4 kilometers). Any mammals moving east or west between the airstrip on the south and the Central Pad on the coast would be required to cross the gravel access road and then the surface mounted freshwater pipeline. Within about 0.75 miles (1.2 kilometers) of the Central Pad, mammals moving east or west would cross additional pipeline corridors (sales and gathering lines).

For caribou, a maximum pipe height of 16 inches (41 centimeters) would be unlikely to obstruct movements, although reactions, including deflected movements and reduced crossing success would be expected. Reges and Curatolo (1985) conducted an experimental pipe-on-ground experimental study in 1984 and found significant differences in caribou crossing success between a “hypothetical pipeline” (staked line on the tundra in an adjacent reference area) and a 1.4-mile (2.25 kilometer) stretch of simulated 8-inch-diameter (20-centimeter) pipeline (made of Sonotube) elevated on rebar supports to various top heights (14, 20, 30, and 42 inches [36, 51, 76, and 107 centimeters]). Although some animals jumped over, most caribou paralleled the simulated pipeline, apparently looking for crossing sites, and usually went around the end of the structure. Caribou crossed the 14-inch (36 centimeter) height significantly more often than an adjacent section of 30-inch (76 centimeter) height, however. Because the proposed water pipeline will be routed adjacent to the busiest section of road and because the various sales and gathering lines also intersect the area within about 0.75 miles of the Central Pad, combined effects of these structures are likely to contribute to lower crossing success, delays in movement and aggregation of animals in the affected area, and deflected movements (Curatolo and Murphy 1986; Curatolo and Reges 1986; Cronin et al. 1994). As previously indicated, large numbers of caribou are very likely to move through the Project area, possibly on multiple occasions each season, during post-calving and insect season movements. Most of these movements have an east–west component that would bring large numbers of caribou into contact with the freshwater pipeline and adjacent roads and pipelines in the vicinity of the Central Pad, airstrip, and gravel mine/freshwater source. Overall, the freshwater pipeline will contribute to moderate effects of the Project on caribou.

Reactions of other mammals to the proposed freshwater pipeline are uncertain. Young muskoxen may be inhibited or prevented from crossing, but very few muskoxen are anticipated to encounter the Project. Most other mammals would likely be able to cross over or under the pipeline at will. The proposed freshwater pipeline is unlikely to affect mammals other than caribou and muskoxen.

Population/Mortality/Injury Effects

Attraction and Human-Animal Interaction

Human-animal interactions would occur during all seasons and all three Project phases of the Project, but may occur most frequently during the Construction phase, when human activity would be most intensive and wide-ranging. Lower levels of human activity during the Drilling and Operations phases would result in a lower rate of human-animal interactions. The rate of human-animal interactions is further increased by the attraction of opportunistic predators/scavengers, specifically foxes, bears, gulls, and ravens, to areas of human activity. The consequences of increased interaction between humans and animals differs among species, but the most important causes of attraction of animals are human foods and garbage or to artificial habitats (e.g., caribou coming onto gravel pads for insect relief).

Attraction to oil field facilities and increased interaction with humans creates the potential for mortality from control measures (i.e., killing problem animals), vehicle strikes, or ingestion of toxic substances, as well as potential injury to humans from rabies or aggressive behavior. Another effect of artificially increased numbers of bears and foxes (and gulls and ravens) is increased rates of nest predation for small mammals, colonially nesting geese, endangered eiders, and other waterfowl, shorebirds, and passerines (Day 1998), an effect that is discussed in Section 4.2.6 Terrestrial Mammals and in Section 4.2.4 Birds. In existing North Slope oil fields, regulations prohibiting the feeding of wildlife are generally enforced, and modern garbage-handling procedures and heightened awareness in the oil fields have greatly reduced the effects of artificially increased food resources on bears, although their affect on foxes, ravens, and gulls is less clear. All of these predator/scavengers continue to be attracted to the oil fields, with various indirect effects. For most terrestrial mammals, the effects of human-animal interactions associated with the Project are expected to be minor during all three development phases. For arctic foxes and grizzly bears, the effects of human-animal interactions are expected to increase from minor during the Drilling phase to moderate during the Construction and Operations phases. The primary effect to caribou from increased human interactions and seasonal attraction to oil field facilities is mortality from vehicle collisions, a minor effect that is discussed above under Noise and Traffic.

Foxes and bears can be attracted to areas of human activity where they readily feed on garbage and handouts (Eberhardt et al. 1982; Follmann 1989; Follmann and Hechtel 1990; Truett 1993; Shideler and Hechtel 2000). Foxes and, to a lesser extent, bears also may use human structures—such as gravel berms, culverts, and empty pipes—for denning (Burgess et al. 1993; Shideler and Hechtel 2000). Arctic foxes and bears both benefit from increased food resources in the oil fields (Burgess 2000; Shideler and Hechtel 2000). When organic refuse is abundant, attracted foxes experience increased survivorship and higher reproductive rates (Eberhardt et al. 1982; 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, 1983; Burgess et al. 1993; Burgess 2000). The density of arctic foxes in the oil fields during winter is much greater than in surrounding tundra, and some foxes remain resident in the oil fields year-round, in contrast to the nomadic existence of most arctic foxes in winter (Follmann and Martin 2000). Similarly, grizzly bears in the Prudhoe Bay and Kuparuk oil fields have larger litters, higher growth rates, and greater body sizes than bears elsewhere on the coastal plain, evidently because of supplemental foods from artificial sources (Shideler and Hechtel 1993, 2000).

The positive effect of supplemental foods on body condition of individual foxes and bears is countered, however, by fox and bear control measures that are implemented in the oil fields to deal with problem animals, with very different long-term effects on foxes versus bears. Arctic fox populations fluctuate dramatically because of a high potential reproductive rate and natural factors, primarily disease and starvation, that periodically reduce numbers. Fox control measures, including relocations and kill-traps, are implemented when specific animals become problems or when the abundance of foxes is deemed to represent a risk to personnel because of rabies. Control measures are implemented periodically to control fox numbers when they are abundant, but such measures result in only temporary decreases in the local abundance of foxes.

In contrast, DLP mortality (the killing of bears in defense of life and property), has the potential to affect the regional North Slope population of grizzly bears. Grizzly bears have the lowest reproductive potential of any North American land mammal and, as such, populations can be very sensitive to changes in mortality. Before the enforcement of modern garbage-handling practices in the North Slope oil fields, an increase in the abundance of grizzly bears and associated human-bear interactions became apparent. When access to garbage and human food was suddenly eliminated, food-conditioned bears suffered DLP mortalities at greater-than-sustainable rates (Shideler and Hechtel 2000; NRC 2003). Post-weaned subadults also experienced greater-than-average mortality because their conditioning to human foods made them more vulnerable to hunters and to DLP killings outside of the oil fields. These interactions may have created a population sink associated with industrial infrastructure that could lead to long-term effects on grizzly bear populations on the North Slope (NRC 2003).

In summary, the three gravel pads for the Project are likely to be visited by arctic foxes (and possibly red foxes) throughout the year; by grizzly bears in spring, summer, and fall; and by caribou mainly during the summer insect season. It is expected that refuse-control efforts, on-site incineration of waste, employee environmental sensitivity training, and enforced rules against animal feeding would minimize population-level effects on arctic foxes and grizzly bears. Nonetheless, artificial food sources are powerful attractants and the Project may attract numbers of foxes and bears. Control measures, including fox trapping and DLP kills of bears, may be necessary on occasion during the Project. Such mortality would be expected to have moderate effects on foxes and grizzly bears.

The habituation of arctic foxes and grizzly bears to human activity not only increases the risk of injury or mortality of those animals, but also increases the potential for infection of humans and other animals with rabies or other diseases and to harm humans through aggressive behavior. Fox trapping in the Prudhoe Bay and Kuparuk oil fields to reduce the abundance of arctic foxes is undertaken in large part to reduce risks associated with rabies. Rabies is endemic in arctic foxes and incidents of potential exposure of oil field workers to rabid foxes have occurred. Increased numbers of bears similarly increase the risks of a potentially serious or fatal encounter for oil field workers. Employee training programs in the existing North Slope oil fields include wildlife safety and protection and minimize serious wildlife-human encounters. Similar practices at the Project would minimize risks associated with human-wildlife encounters. The reader is referred to the grizzly bear section of the Bear Interaction Plan.

Increased Predation

Increased predation associated with increased abundance of predators has been difficult to document conclusively, but is considered to be an effect in existing North Slope oil fields (Martin 1997; Day 1998). Among terrestrial mammals, increased predator populations around oil field developments may increase predation of lemmings and voles, ground squirrels, and ungulates, particularly ungulate calves. This effect is inferred from the higher numbers and productivity of foxes (Eberhardt et al. 1982; Burgess et al. 1993; Burgess 2000), grizzly bears (Shideler and Hechtel 1995b; Shideler and Hechtel 2000), and gulls and ravens (Truett et al. 1997; Day 1998; Powell and Backensto 2009) in the North Slope oil fields and is of particular concern for breeding birds (see Section 4.2.4). Arctic foxes, gulls, and ravens prey on lemmings and voles and increases in their abundance may affect small mammal populations, although there is little information about lemming and vole populations in oil fields and no information suggesting such a population-level effect of increased predation. Although grizzly bears are known to prey on caribou in the region (Shideler and Hechtel 2000; ABR 2007), the magnitude of mortality is difficult to quantify. Arctic ground squirrels are also consumed by both arctic foxes and grizzly bears, and local populations may be affected by increased populations of those predators. Refuse-control efforts, environmental sensitivity training of employees, and strict enforcement of rules prohibiting animal feeding would minimize population-level effects on predators and scavengers. Nonetheless, arctic foxes, grizzly bears, ravens, and gulls would be attracted to the Project facilities and their numbers likely would increase locally, with consequent increases in mortality of prey. It is expected that development of the Project would result in higher densities of predator/scavengers, but that the effects of increased predation would be minor for lemmings, voles, ground squirrels, and caribou.

Spills, Leaks, and Contamination

Refer to discussion under Drilling phase. Spills, leaks, and contamination at the Project are anticipated to have minor effects on habitats of terrestrial mammals during the Construction phase.

4.2.6.3 Operations

Some limited use of ice roads to access the Project area may occur during the Operations phase (see discussion of the effects of ice roads on mammals above in Sections 4.2.6.1, Drilling and 4.2.6.2, Construction).

Habitat Loss and Alteration

Snow Dumps and Snow Drifts

Refer to discussion under Drilling phase. Snow dumps and snow drifts at the Project site are expected to have minor long-term effects on habitats of terrestrial mammals during the Operations phase.

Obstruction of Flow

Refer to discussion under Construction phase. Obstruction of flow at the Project site is expected to have minor effects on terrestrial mammal habitats during the Operations phase.

Dust Fallout

Low anticipated traffic volumes during the Operations phase and dust control measures (e.g., watering of roads) and enforced traffic speed limits should minimize the effects of early snowmelt because of dust fallout. The lower rates of traffic during the Operations phase would reduce the extent of dust fallout, but the effect would persist throughout the life of the Project. Additional details are provided under Construction phase.

Thermokarst

Thermokarst is a natural process that acts constantly and exerts strong control on tundra landscapes through alterations in microrelief and soil moisture. Because shallow permafrost reacts to short- or long-term surface disturbances, habitat alterations can be anticipated near such sites. Habitat alterations because of thermokarst can include increased diversity of wet, moist, and dry habitats or, if severe, thermokarst can result in the creation of large, deep waterbodies. Although long-lasting visual and hydrologic effects result from thermokarst (Lawson 1986), thermokarst has both positive and negative effects on wildlife habitats (Truett and Kertell 1992). Many of the ecological changes associated with thermokarst may benefit plant productivity and wildlife use (Truett and Kertell 1992). Thermokarst may improve habitat diversity, species richness, and plant growth on thin gravel fill (Jorgenson and Joyce 1994). 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 Project area, and both species groups may benefit from the availability of grazing plants with higher nutritional value (McKendrick 1981). In one study of habitat use, severely disturbed tundra associated with a peat road had higher use (in relation to availability) than most other undisturbed habitats in Prudhoe Bay (Murphy and Anderson 1993). Overall, however, data are insufficient to assess the net effect of thermokarst on wildlife populations (Truett and Kertell 1992).

Disturbance Effects

Noise and Traffic

Refer to discussion under Construction phase. Noise and traffic at the Point Thomson Project are expected to have moderate effects on caribou during the Operations phase, primarily during the calving and insect seasons. Effects would be minor for other terrestrial mammals.

Population/Mortality/Injury Effects

Attraction and Human-Animal Interaction

Refer to discussion under Construction phase. Human-animal interactions at the Project site are expected to have moderate effects on grizzly bears during the Operations phase. Effects would be minor for other terrestrial mammals.

Increased Predation

Refer to discussion under Construction phase. Increased predation associated with higher densities of predator scavengers at the Project area is expected to have minor effects on populations of terrestrial mammal prey.

Spills, Leaks, and Contamination

Refer to discussion under Drilling phase. Spills, leaks, and contamination at the Project area are anticipated to have minor effects on populations of terrestrial mammals.

4.2.7 Threatened and Endangered

This section evaluates the potential environmental consequences on the characteristics of the existing environment, as described in 3.2.7. Consequences are presented for drilling, construction, and operations. One endangered species (bowhead whale), two threatened species (Spectacled Eider and polar bear), and one candidate species (Yellow-billed Loon) may be found seasonally in the vicinity of the Project. Steller's Eiders, also a threatened species present on the North Slope, generally occur west of the Project area and, therefore, the environmental consequences of the Project are not discussed for this species. The potential effects of the Project on threatened and endangered species are summarized in Tables 4-23 through 4-26.

4.2.7.1 Bowhead Whale

The environmental consequences of the Project to bowhead whales are described for drilling, construction, and operations. The Project is expected to have no more than a short-term and temporary effect on a small number of bowhead whales if any. Mitigation measures, including those stipulated by the NMFS and USFWS in the incidental take permits for the Project are expected to result in the Project having a no more than a minor effect on the bowhead population or subsistence.

Drilling

Drilling will require transport of materials by barge and ice roads and the transport of workers by aircraft. Drilling will occur during winter and summer (late spring to early fall) on land-based gravel pads and potentially ice pads, which are expected to have no effect on bowhead whales. Barging will occur during summer and involve moving materials from Prudhoe Bay to the site where the barges will be grounded for unloading of materials. Barging will occur inside of the barrier islands where the tugs transporting the barges are not likely to encounter bowhead whales. Any barging outside the barrier islands could encounter small numbers of bowhead whales primarily during the fall migration. The underwater noise and presence of the tug pushing the barge could cause bowhead whales to alter their location or change behavior, but any effects are expected to be minor since they will be short term, temporary and limited to a very small number of bowheads encountered along the transportation route. It is possible but unlikely that a vessel could strike and injure a bowhead whale, since the vessels will be slow moving and there are no documented reports of vessels striking bowhead whales in their range.

Grounding of the barges is expected to have no effect on bowhead whales, since it would occur well within the barrier islands and sound transmission would be muted by shallow water location of the grounding.

Ice roads will be built and maintained on the sea ice near shore during winter when bowheads are not present in the Beaufort Sea. Therefore, ice road construction and maintenance will have no effect on bowhead whales.

Construction

Aircraft transporting workers to and from the site could affect bowhead whales from spring through fall. Low flying aircraft and helicopters have been demonstrated to cause temporary and short-term changes in bowhead whale behavior (Richardson et al. 1995). Implementing proven mitigation measures can prevent effects on bowhead whales. These include avoiding flying over water during spring to fall and/or flying at altitudes scientifically demonstrated to not disturb bowhead whales (>457 meters or >1,500 feet). Flights over ice during winter will not affect bowhead whales for reasons stated above; therefore, the potential effects of aircraft on bowhead whales would be none to minor.

Increased marine traffic is expected to potentially expose bowhead whales to disturbance more frequently than during the drilling phase. Few, if any, bowhead whales would be affected by activities occurring within the barrier islands since most occur beyond these islands. Barging outside of the barrier islands could encounter more whales, but still a small number of bowhead whales, since they are widely distributed over the outer continental shelf during the fall migration (Treacy et al. 2006). Effects from increased traffic on bowhead whales are expected to result in short-term and temporary disturbances in behavior as reported in a number of studies (Richardson et al. 1995; LGL and Greeneridge 2001). Implementation of mitigation, including onboard marine mammal observers, vessels altering courses to avoid bowhead whales, and aircraft flying above altitudes known to not cause disturbance to bowhead whales are expected to have no more than a minor effect on bowhead whales.

TABLE 4-23: SUMMARY OF THE LIKELY EFFECTS ON BOWHEAD WHALES

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling and Construction					
Disturbance (Vessel And Aircraft)	Low (very low numbers of bowheads in the regions during the open water period and limited disturbance expected)	Regional	Temporary (sea lift barges will travel outside of the barrier island during two week period in summer during construction phase)	Unique	Minor
Collision Effects (Vessels)	Low (very low numbers of bowheads in the regions during the open water period and limited encounters expected)	Regional	Temporary (sea lift barges will travel outside of the barrier island during two week period in summer during construction phase)	Unique	None to minor
Operations					
Disturbance Effects	Low (very low numbers of bowheads in the regions during the open water period and limited disturbance expected)	Regional	Temporary (Barges for re-supply will travel within the barrier island each summer for life of project)	Unique	Minor
Mortality Effects					
Oil And Contaminant Spills Or Leaks	Low (rare events and low number of bowhead in the area during open water period)	Regional	Temporary	Unique	None to minor
Collisions Effects (Vessels)	Low ((very low numbers of bowheads in the regions during the open water period and limited encounters expected)	Regional	Temporary (Barges for re-supply will travel within the barrier island each summer for life of project)	Unique	One

Notes:
[1] Intensity (severity) = low, medium, high
[2] Scope / Magnitude (geographic) = local, regional, national/international (e.g., for migratory species)
[3] Duration = temporary, long-term, permanent
[4] Context = common, important, unique (Spectacled Eider treated as unique because of their threatened status under the ESA)
[5] Overall = none, minor, moderate, major. The effects being assessed for each project activity/component are: 1) Disturbance from vessels and aircraft; 2) Mortality from collision mortality from vessels; 3) Mortality effects from oil and contaminant spills.

TABLE 4-24: SUMMARY OF THE LIKELY EFFECTS ON POLAR BEARS

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling					
Habitat Loss And Alteration	Low (project in low-density terrestrial denning area; ice roads/pads must avoid active maternal dens by 1 mile)	Local	Temporary (winter only, due to project scheduling)	Unique	Minor (negligible with required mitigation in place)
Disturbance Effects	Low (ice roads and pads sited 1 mile from active dens; disturbance of non-denning bears moving through area likely to involve short-term avoidance responses)	Local	Temporary (winter only, due to project scheduling)	Unique	Minor (negligible with required mitigation in place)
Injury And Mortality Effects	Low (mitigation required by ITR/LOA process is effective at minimizing injury and mortality)	Local	Temporary (winter only, due to project scheduling)	Unique	Minor (negligible with required mitigation in place)
Construction					
Habitat Loss And Alteration	Low (all roads and pads sited 1 mile from active dens; minor losses of potential denning habitat in current project footprint; critical habitat consultation will minimize losses)	Local	Temporary (ice roads/pads during two–three year period) or Permanent (gravel mine/airstrip/roads/pads)	Unique	Minor (negligible with required mitigation in place)
Disturbance Effects	Low (ice roads and pads sited 1 mile from active dens; disturbance of non-denning bears moving through area likely to involve short-term avoidance responses)	Regional	Temporary (late summer through late winter, during two–three year period)	Unique	Minor (negligible with required mitigation in place)
Injury And Mortality Effects	Low (mitigation required by ITR/LOA process is effective at minimizing injury and mortality)	Regional	Temporary (late summer through late winter, during two–three year period)	Unique	Minor (negligible with required mitigation in place)
Operations					
Habitat Loss And Alteration	Low (no further loss of denning habitat after construction; maintenance using ice roads must avoid dens by 1 mile)	Local	Permanent	Unique	Minor (negligible with required mitigation in place)
Disturbance Effects	Low (maternal bears presumed to avoid denning near facilities; disturbance of non-denning bears moving through area likely to involve short-term avoidance responses)	Regional	Long-term (life of project)	Unique	Minor (negligible with required mitigation in place)
Injury And Mortality	Low (mitigation required	Regional	Long-term (life of	Unique	Minor (negligible with

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Effects	by ITR/LOA process is effective at minimizing injury and mortality)		project)		required mitigation in place)

Notes:
1 Intensity (severity) = low, medium, high
2 Scope / Magnitude (geographic) = local, regional, national/international
3 Duration = temporary, long-term, permanent
4 Context = common, important, unique (the polar bear is a unique and ecologically important arctic predator)
5 Overall = none, minor, moderate, major. The potential effects considered for each project activity/component were: (1) short-term habitat loss from construction of ice roads and pads; (2) long-term habitat loss from gravel extraction and stockpiling at mine site and gravel placement for construction of gravel pads, airstrip, and interconnecting road system; (3) behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats; (4) attraction to project facilities (e.g., to artificial food sources); (5) injury and mortality of wildlife from vehicle collisions and from contact with or ingestion of contaminants.

TABLE 4-25: SUMMARY OF THE LIKELY EFFECTS ON YELLOW-BILLED LOONS

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling and Construction					
Habitat Loss And Alteration	Low (low loon numbers and few suitable lakes for loons in the project area; minor effects on prey expected in marine waters)	Local	Permanent (gravel roads and pads) and temporary (ice roads/pads and dredging for barge landings)	Unique	None to minor
Disturbance	Low (low loon numbers and temporary displacement effects during sea-lift events; gravel placement for roads and pads would occur during winter)	Local	Temporary (during sea-lift events)	Unique	Minor
Mortality Effects	Low (small collision risk with onshore infrastructure as loons primarily migrate in nearshore waters; temporary collision risk during sea-lift events)	Local	Long-term (infrastructure will remain for life of project) and temporary (during sea-lift events)	Unique	Minor
Operations					
Habitat Loss And Alteration	Low (low loon numbers and few suitable lakes for loons in the project area)	Local	Long-term (snow dumps and drifts) and temporary (offshore and/or onshore ice roads may be used periodically during operations)	Unique	None
Disturbance Effects	Low (low loon numbers and low levels of disturbing activities expected during operations)	Local	Long-term	Unique	None to minor (up to moderate if nearshore activities are common)
Mortality Effects					
Oil And Contaminant Spills Or Leaks	Low to high (although rare events)	Local	Temporary	Unique	Minor to major (effects would vary depending on the nature of the spill)
Collisions With Vehicles Or Infrastructure	Low (small collision risk with infrastructure as loons primarily migrate	Local	Long-term (infrastructure will remain for life of project)	Unique	Minor

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
	offshore; temporary offshore collision risk during sea-lift events)		and temporary (during sea-lift events)		
Increased Predation	Low (low loon numbers and few suitable lakes for loons in the project area)	Local	Long-term	Unique	None to minor

Notes:
[1] Intensity (severity) = low, medium, high
[2] Scope / Magnitude (geographic) = local, regional, national/international (e.g., for migratory species)
[3] Duration = temporary, long-term, permanent
[4] Context = common, important, unique (Yellow-billed Loon treated as unique because of their candidate status under the ESA)
[5] Overall = none, minor, moderate, major. The effects being assessed for each project activity/component are: 1) long-term habitat loss from gravel extraction and stockpiling at the mine site and gravel placement for the construction of three gravel pads, the airstrip, and the interconnecting road system; 2) temporary habitat loss from soil compaction, disturbance of vegetation, and persistent accumulation of snow and ice following the use of temporary ice roads and work pads; 3) changes in the use of habitats altered by dust fallout, gravel spray from snow removal, persistent snow drifts, thermokarst, water flow alteration and impoundments, water withdrawal, and contaminants; 4) behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats; 5) attraction to project facilities (e.g., herbivorous birds to areas of early snowmelt in spring, predatory and scavenging birds to artificial food sources); 6) increased mortality from predator populations if predators increase as a result of the availability of anthropogenic foods, 7) injury and mortality of birds from vehicle collisions, collisions with overhead wires, towers, or facility buildings, and from contact with or ingestion of contaminants, and 8) long-term habitat loss due to accidental spills.

TABLE 4-26: SUMMARY OF THE LIKELY EFFECTS ON SPECTACLED EIDERS

Project Phase Project Activity/Component	Assessment Criteria				Overall Effect[5]
	Intensity[1]	Scope / Magnitude[2]	Duration[3]	Context[4]	
Drilling and Construction					
Habitat Loss and Alteration	Low (low eider numbers in the project area; limited loss of potential habitat to development)	Local	Permanent (gravel roads and pads)	Unique	Minor
Disturbance	Low (low eider numbers in the project area and limited disturbance expected)	Local	Long-term	Unique	Minor
Mortality Effects	Low (small collision risk with onshore infrastructure or during sea-lift events as eiders primarily migrate in offshore waters)	Local	Long-term (infrastructure will remain for life of project) and temporary (during sea-lift events)	Unique	Minor
Operations					
Habitat Loss and Alteration	Low to medium (low eider numbers in the project area but nest displacement could occur >1 year)	Local	Long-term (snow dumps and drifts) and temporary (offshore and/or onshore ice roads may be used periodically during operations)	Unique	Minor to moderate
Disturbance Effects	Low (low eider numbers and low levels of disturbing activities expected during operations)	Local	Long-term	Unique	None to minor
Mortality Effects					
Oil and Contaminant Spills or Leaks	Low (rare events and low eider nesting densities)	Local	Temporary	Unique	Minor
Collisions with Vehicles or Infrastructure	Low (small collision risk with infrastructure as eider nesting densities are low and eiders primarily migrate in offshore waters)	Local	Long-term (infrastructure will remain for life of project) and temporary (during sea-lift events)	Unique	Minor
Increased Predation	Low (low eider numbers in the project area)	Local	Long-term	Unique	Minor

Notes:
1 Intensity (severity) = low, medium, high
2 Scope / Magnitude (geographic) = local, regional, national/international (e.g., for migratory species)
3 Duration = temporary, long-term, permanent
4 Context = common, important, unique (Spectacled Eider treated as unique because of their threatened status under the ESA)

[5] Overall = none, minor, moderate, major. The effects being assessed for each project activity/component are: 1) long-term habitat loss from gravel extraction and stockpiling at the mine site and gravel placement for the construction of three gravel pads, the airstrip, and the interconnecting road system; 2) temporary habitat loss from soil compaction, disturbance of vegetation, and persistent accumulation of snow and ice following the use of temporary ice roads and work pads; 3) changes in the use of habitats altered by dust fallout, gravel spray from snow removal, persistent snow drifts, thermokarst, water flow alteration and impoundments, water withdrawal, and contaminants; 4) behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility) during project construction, development drilling, and operation, resulting in altered distribution, movements, and reduced use of seasonal habitats; 5) attraction to project facilities (e.g., herbivorous birds to areas of early snowmelt in spring, predatory and scavenging birds to artificial food sources); 6) increased mortality from predator populations if predators increase as a result of the availability of anthropogenic foods, 7) injury and mortality of birds from vehicle collisions, collisions with overhead wires, towers, or facility buildings, and from contact with or ingestion of contaminants, and 8) long-term habitat loss due to accidental spills.

Construction-related noise at the site is expected to be primarily airborne noise which will have no effect on bowhead whales.

Operations

Operations are expected to have similar effects on bowhead whales as construction, since they will involve many of the same activities with the addition of potential oil spills. Operations could have a minor effect on bowhead during late summer or the fall migration. Similar to construction, operations effects are expected to be temporary, short-term, and limited no more than a small number of bowhead whales, and would therefore be considered minor. A very small proportion (<1 percent) of the bowhead population is expected to be exposed to operations activities, since most bowheads occur outside of the barrier islands and they are widespread on the outer continental shelf. Implementation of mitigation measures described for drilling and construction is expected to result in operations having none to minor effects on bowhead whales.

An oil spill during operations is unlikely to affect bowhead whales, even during spring break-up of the sea ice. While oil is difficult to recover in broken sea ice compared to solid ice, open water, or on land, most bowheads would be considerably beyond the barrier islands during the spring migration and widely distribution in time and space. Historically, most spills during operations have been small and quickly contained by the oil and gas company. In addition, the oil and gas companies have oil spill response teams highly-trained in spill containment and recovery. Warning systems are also in place for operators to quickly detect a spill and respond. Both the spill response teams and warning systems are expected to prevent most spills from becoming large enough to have an effect on bowhead whales. Therefore, potential effect of an oil spill on the bowhead whale would be none to minor.

4.2.7.2 Polar Bear

Human activities that potentially could affect polar bears are regulated by the USFWS under both the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA), with the former law taking precedence in the permitting process regarding incidental take. Government agencies charged with approving permits for a development project must consult with USFWS under Section 7 of the ESA regarding the potential effects of the Project on polar bears and proposed critical habitat. The principal mechanism for regulating human activities is the review and approval of Incidental Take Regulations (ITRs), which are established under Section 101(a)(5) of the MMPA for 5-year periods to regulate the nonlethal, incidental, unintentional taking of small numbers of polar bears (under MMPA, take means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill”). Take is permitted under the ITRs provided that it would result in negligible impacts on the species and would not have an unmitigable adverse impact on the availability of the species for subsistence use by Alaska Natives.

Activities related to oil and gas exploration and development in the Beaufort Sea region of northern Alaska currently are subject to an ITR rulemaking in effect from 2 August 2006–2 August 2011 (71 FR 43926) (FR 2006). The federal review for that rulemaking resulted in a negligible-impact finding for following potential impacts at the levels discussed in the review, provided that mitigative measures were implemented: (1) noise disturbance from stationary sources, mobile sources, vessel and aircraft traffic, and seismic exploration; (2) physical obstructions to movement, such as causeways, roads, or artificial islands; (3) human encounters; and (4) effects on prey species, mainly from spills but also from short-term local disturbance (USFWS 2006; FR 2006). Under the ITRs, annual Letters of Authorization (LOAs) are issued for specific activities or projects, which are subject to mitigative and monitoring requirements (described in 50 CFR Part 18, Subpart J), and which require project-specific interaction plans as the primary means of mitigating the potential effects of the permitted activities on polar bears, including site-specific monitoring and reporting requirements.

Although the current ITRs were approved in 2006 before the polar bear was listed as threatened under the ESA, a subsequent analysis and Biological Opinion (USFWS 2008b) concluded that the ITR rulemaking and the activities it authorized did not jeopardize the species, provided that mitigative measures were in place. A separate analysis conducted for pending offshore lease sales (MMS 2008) produced another Biological Opinion (USFWS 2009b) that reached a similar no-jeopardy conclusion, although several adverse effects (disturbance, oil spills, and human interactions) were considered possible outcomes from the seismic surveys and exploratory drilling activities that were the subject of that analysis.

The proposed designation of critical habitat for polar bears in northern and western Alaska announced on 22 October 2009, to the extent implemented as a final rule, will result in consultation with USFWS under ESA Section 7. That consultation will evaluate and mitigate the potential effects of the Project on the three proposed units of critical habitat (sea ice habitat, terrestrial denning habitat, and barrier island habitat).

Drilling

The initial drilling phase of the Project will occur during winter, so the potential for effects on polar bears will be relatively high because the use of coastal habitats by bears is highest from late summer/autumn through late winter. Drilling and associated support activities have the potential to cause the following effects on polar bears: (1) loss or alteration of maternal denning habitat; (2) increased disturbance of bears caused by human activity, associated noise, and traffic, which is of particular concern for maternal females in dens; (3) decreased survival of young cubs if disturbance results in den abandonment; and (4) increased frequency of encounters with humans and vehicles, increasing the risk of injury or mortality.

Habitat Loss and Alteration

The proposed ice roads and ice pads for the Point Thomson Project would directly affect at least 12 proposed segments of mapped potential denning habitat (i.e., the terrestrial denning unit of proposed critical habitat), totaling an estimated 1.1 acres, assuming an average width of 21 feet (6.4 meters) for the segments of potential denning habitat mapped by Durner et al. (2001, 2006). The sea-ice road extending from the Endicott access road to the Point Thomson Project will transect 48.2 miles (77.5 kilometers) of coastal habitat, much of which closely approaches and parallels potential denning habitat (depicted in Figure 3-28). The sea-ice road route closely follows the coast, including spits that have been proposed as part of the barrier islands unit of proposed critical habitat, and crosses other stretches of the sea-ice unit of proposed critical habitat.

The current ITRs require that surveys of potential denning habitat be conducted along the entire route within a 1-mile (1.6-kilometers) buffer surrounding all ice roads and pads. The use of forward-looking infrared (FLIR) sensors has proven to be an effective means of locating dens in such surveys, as have specially trained dogs (Amstrup et al. 2004; York et al. 2004; Perham 2005; Shideler 2003, 2009). An estimated area of 92.1 acres (37.3 hectares) of potential denning habitat occurs within the 1-mile buffer around the proposed ice roads and pads (which totals approximately 136.2 square miles [352.8 square kilometers]), and at least seven maternal dens have been located in this buffer in past years. USFWS den records (Perham 2009) show that at least six maternal dens were occupied on the Sagavanirktok River delta from 2002 to 2009, two of which were located on the eastern delta, across which the sea-ice road would be built, although they were outside of the 1-mile buffer surrounding that route. Because polar bears begin to den before the ice roads and pads would be constructed, the locations of the ice roads or pads would need to be shifted to avoid any active dens discovered during the den survey.

Water withdrawal from lakes for the construction of ice roads and pads would not be likely to cause any adverse effects on polar bear habitat, provided that no occupied dens occur within a mile of the withdrawal sites. Similarly, the presence of snow dumps and drifts in the vicinity of the facilities used to support the drilling phase would have none to minor effects on polar bear habitat.

Accidental spills, leaks, and contamination likely would pose none to minor effects on polar bear habitat, in view of the relatively small amounts of material used during the drilling phase, the safeguards in place as part of the spill contingency plan, and the ability to detect and clean up such spills quickly.

In summary, the effects of habitat loss and alteration on polar bears during the drilling phase are expected to be none to minor, assuming that the mitigation required by the ITRs and critical habitat consultation is in place.

Disturbance Effects

Noise and visual disturbance from drilling and associated human activity, especially aircraft and vehicle traffic, have the potential to disturb polar bears in the vicinity of those activities (Perham 2005; USFWS 2006c, 2008b, 2009b). The greatest concern is disturbance of maternal females during the winter denning period, possibly resulting in den abandonment (Amstrup 1993; Linnell et al. 2000; Durner et al. 2006). Polar bear dens are known to occur in the Point Thomson area (Figure 3-28) and the incidence of denning in terrestrial areas appears to be increasing (Fischbach et al. 2007), so the potential for disturbance of dens during the drilling phase of the Project is of concern.

Amstrup (1993) found that 10 of 12 denning polar bears tolerated exposure to a variety of disturbing stimuli near dens with no apparent change in productivity (survival of young). Polar bears may be more likely to abandon dens in response to disturbance early in the denning period than later (Amstrup 1993), but abandonment later in the denning period appears to exert greater effects on productivity; Amstrup and Gardner (1994) found that survival was poor for cubs that left dens prematurely due to movement of sea ice. Amstrup (1993) suggested that initiation of intensive human activities during the period when females seek den sites (October–November) would give them the opportunity to choose sites in less-disturbed locations.

Experimental studies of noise and vibration in artificial (human-made) "dens" have been used to estimate the distances at which disturbance may occur. Blix and Lentfer (1992) reported that snow cover greatly attenuated sounds and concluded that activities associated with oil and gas exploration and development, such as seismic surveys and helicopter overflights, would not be likely to disturb denning bears at distances greater than 328 feet (100 meters) from dens. In a more detailed study, MacGillivray et al. (2003) compared noise levels inside and outside of artificial dens on Flaxman Island during a variety of industrial remediation activities, including passage by different vehicles and overflights by helicopters, in March 2002. Although snow cover was found to provide an effective noise buffer, the probable detection distances of various stimuli ranged from <0.3 mile (0.5 kilometers) to 1.2 miles (2 kilometers) away from the dens.

Den surveys using FLIR sensors or trained dogs would be conducted before construction of ice roads and pads commences, as stipulated by the LOAs that will need to be issued for the Project and as specified in the interaction plan. If dens are detected, the locations of ice roads and pads will be moved to avoid den locations by the 1-mile buffer distance required by the current ITRs, thereby reducing the effects on occupied dens to none to minor levels.

Polar bears that are not occupying maternal dens may be disturbed by Project activities, particularly aircraft overflights, but such disturbances are likely to result in short-term behavioral responses that would have no population-level effects and thus are considered less problematic than den disturbance and abandonment (USFWS 2009b). Detection of bears by trained monitors will allow Project activities to be modified to avoid or minimize disturbance of bears moving through the Project vicinity.

In summary, Project-related disturbance is likely to result in none to minor effects on the productivity of polar bears in the Point Thomson area, assuming that all required mitigative measures are implemented, as required under the current ITRs and specified in the interaction plan.

Injury and Mortality Effects

When the polar bear was listed as a threatened species in 2008 (73 FR 28212) (FR 2008), the USFWS noted that the factors contributing to the primary threat identified in the listing analysis (rapidly diminishing sea-ice habitat) could not realistically be regulated under their management purview. Therefore, in lieu of influencing the causes underlying climate change, such as greenhouse gas emissions, USFWS focused on factors more likely to be controllable, such as habitat protection and the prevention and reduction of lethal take. The result of this approach is that even greater emphasis will be devoted to mitigation through interaction planning to avoid and minimize injury and mortality of polar bears (Miller 2009).

Polar bears are curious and opportunistic hunters, frequently approaching and investigating locations where human activity occurs. Proximity to humans poses risks of injury and mortality for both bears and humans and may result in the need to engage in non-lethal take such as hazing or, on rare occasions, in lethal take in defense of human life. Stirling (1988) reported that polar bears commonly approached industrial sites in the Canadian Beaufort Sea. Encounters between polar bears and humans in the Point Thomson area are most likely to occur along the coastline and barrier islands in late summer/autumn (late August–November) and late winter/spring (March–May). Sightings of polar bears at industrial sites in the Beaufort Sea region of Alaska have increased in recent years, in keeping with increasing use of coastal habitats as summer sea-ice cover has diminished (Schliebe et al. 2008; USFWS 2008b), and sightings and hazings have increased, although no lethal take or injuries have been reported (USFWS 2008b, 2009). In fact, only two polar bears have been killed in DLP at industrial sites in Alaska since the late 1960s, one was killed in winter 1968–69, and another was killed in 1990 at the Stinson exploration site in western Camden Bay, north of Point Thomson (Perham 2005; USFWS 2006c). None have been killed since the Chukchi Sea and Beaufort Sea ITRs went into effect in 1991 and 1993, respectively. In contrast, 33 polar bears were killed at industrial sites in Canada during 1976–1986 (Perham 2005; USFWS 2006c). In another study, Dyck (2006) reported that 618 polar bears (averaging 20/year) were killed during 1970–2000 in the Northwest Territories and Nunavut in northern Canada, 4 percent of which occurred at industrial sites.

The ITR–LOA process has proven to be effective at addressing and mitigating the risks of polar bear encounters with humans. Besides denning surveys, the required interaction plan stipulates monitoring and reporting of bear sightings and encounters using trained observers, as well as training of personnel in nonlethal means of protection (hazing). Although camps and other activity areas have the potential to attract polar bears, experience demonstrates that these risks can be mitigated effectively by implementing the interaction plan. Procedures include detection systems using monitors and motion/infrared sensors; safety gates, fences, and cages for workers, as well as skirting of elevated buildings; effective waste handling and snow management; chain-of-command procedures to coordinate responses to sightings; and employee education and training programs (Perham 2005; USFWS 2006c, 2008b, 2009b). As with grizzly bears and foxes, all Project operations will be conducted to minimize the attractiveness of the construction sites to polar bears and to prevent their access to food, garbage, or other potentially edible or harmful materials. Trained bear guards will be present during winter drilling activities and all polar bear sightings will be reported immediately. Upon issuance of an LOA by the USFWS, trained personnel have authority under Section 112(c) of the MMPA to haze or otherwise take polar bears under specific circumstances involving the protection of human life.

A second potential source of injury or mortality is premature den abandonment, which is a possible outcome of den disturbance and has been documented as an adverse effect on cub survival (Amstrup and Gardner 1994; USFWS 2008b, 2009b). The precautions against den disturbance in the required interaction plan and the denning surveys prior to construction of ice roads and pads will minimize the likelihood of this potential risk.

A third potential source of injury or mortality is the sea-ice road, a transportation route that will intersect the movement paths taken by females with young moving from terrestrial denning habitat to hunting areas offshore in late winter/spring (March–April), posing a risk of vehicle strikes and disturbance-related distributional shifts. This risk notwithstanding, no vehicle strikes along similar ice roads have been reported in agency documents evaluating impacts on polar bears.

Accidental spills, leaks, and other sources of contamination pose a risk to polar bears. The risk of a major oil spill in the marine environment is considered to pose the greatest risk to the SBS stock of polar bears (Amstrup 2003a; Schliebe et al. 2006; USFWS 2006c, 2008b, 2009b). The risk of a spill of any appreciable size during the drilling phase of the Project is very low, due to the volumes of material being used, the terrestrial base of activities, and the attention given to spill prevention and contingency planning in drilling operations. Smaller releases of contaminants also can have effects, however; Amstrup et al. (1989) documented the death of a polar bear following ingestion of ethylene glycol in a substance used for runway marking. Effective control of potentially toxic substances and careful attention to preventing spills of any size are the key to preventing such injuries.

In summary, although the potential for injury or mortality exists in this area frequented by polar bears, the risks are well understood and effective mitigation is available, as is spelled out in the interaction plan required by the ITR/LOA process. Therefore, with this mitigation in place, the net effects are likely to be none to minor.

Construction

Construction activities will have the potential to disturb polar bears both denning in and traveling through the Project area. The same types of potential effects described above for the Drilling phase could occur during construction: (1) loss or alteration of denning habitat; (2) decreased use of denning habitat due to disturbance (ice road and pad construction, vehicle traffic, equipment operation, and gravel extraction and placement); and (3) increased potential for injury or mortality due to polar bear attraction to areas of human activity. Because the levels of human activity will peak during the Construction phase, the potential for adverse effects on polar bears will exist during this phase. The period of greatest concern will be from late summer through late winter, when coastal movements of polar bears will peak and maternal denning will occur. Although bears could appear onshore in the Point Thomson area in any season, the likelihood is lowest during summer, although the incidence may increase in that season as sea-ice cover continues to diminish in the Beaufort Sea.

Habitat Loss and Alteration

The potential effects on polar bear habitats during construction will be similar to those during the Drilling phase, described above. Den surveys will be required to identify dens before construction begins and Project plans will be modified to avoid occupied dens by 1 mile. Ice roads and pads will be constructed as during the drilling phase, affecting the same areas of potential denning habitat, and additional land area will be affected by gravel extraction and placement for in-field roads and the Central, Eastern, and Western pads. One segment of mapped potential denning habitat would intersect a gravel road, but no known denning habitat would be affected by the gravel airstrip, mine, or pads, and no dens in the historical data set available for this document were located in areas that would be affected directly by gravel excavation and placement. All three pads, but especially the Central Pad and dock complex, would be located closely adjacent to proposed critical habitat (barrier island and terrestrial denning habitat).

In summary, the effects of the Project on polar bear habitat are likely to be negligible with the required mitigation for identification and avoidance of occupied dens in place. This assessment may need to be revised following further consultation with USFWS.

Disturbance Effects

The same concern with regard to the disturbance of denning maternal females applies in this phase of the Project. The magnitude of such effects is potentially greater in this phase, however, because of the higher levels of human activities across a broader area, including the export pipeline route and associated ice pad for construction. Two of the sample of dens confirmed in past years (Figure 3-28) were located within 1 mile of proposed infrastructure (both of them along the export sales pipeline to Badami) and a third den was located only about 80 feet outside the 1-mile buffer. Thus, comprehensive den surveys using FLIR sensors or trained dogs, or both, will be crucial for locating and avoiding occupied dens before construction.

The greater levels of human activity during the construction phase are likely to increase the magnitude of disturbance effects on non-denning bears, which are likely to result in short-term behavioral responses rather than population-level effects.

Overall, the effects of disturbance during the construction phase are likely to be negligible, provided that the mitigation specified in the interaction plan is in place.

Injury and Mortality Effects

The greatest levels of human activity in the project vicinity will occur during the construction phase, creating the highest risk of attraction and possible interaction of polar bears with humans. These high levels of human activity are likely to increase the risk of injury or mortality, although the effects still are likely to be negligible in view of the requirements of the interaction plan, which are known to be effective in minimizing such risks.

Operations

The potential effects of Point Thomson Project operations would be similar to those discussed above, but the timeline will be longer due to the planned operational life of the Project. The longer duration of this Project phase raises the possibility that the magnitude of effects may increase through time if the Southern Beaufort Sea stock continues to decline and the range of the species contracts, as is predicted by U.S. Geological Survey (USGS) scientists (Durner et al. 2009). It is expected, however, that the ITR/LOA process will continue to be used to regulate incidental take and that the documented effectiveness of mitigative measures will be used to avoid or minimize adverse effects on the population of polar bears.

Habitat Loss and Alteration

The Project is expected to have the least potential effect on polar bear habitat through loss or alteration in this phase because no ice roads or pads or new gravel placement are planned. After the placement of gravel pads and roads during the construction phase, the attractiveness of some potential denning habitat in the vicinity of infrastructure may be diminished for maternal females because of the presence of the facilities and associated human activity, but the amount of potential denning habitat in the Point Thomson area (Figure 3-28) is already the lowest in entire area mapped by USGS (Durner et al. 2001, 2006). Thus, the effects on habitat during this phase likely would be negligible.

Disturbance Effects

The same concerns with regard to disturbance of denning maternal females apply in this phase of the Project as in the previous two. The effects are likely to increase during the operational life of the Project, however, if summer ice cover continues to diminish, resulting in more bears being present onshore during the open water period and traveling the coastline more in late summer/autumn. Such an occurrence is projected by various investigators for increasing use of coastal habitats and terrestrial denning habitats (Fischbach et al. 2007; Schliebe et al. 2008; USFWS 2006c, 2008b, 2009b). It is likely that maternal denning will continue to increase in terrestrial habitats in the future, although the presence of the operating Point Thomson facilities would probably discourage female bears from denning nearby. Instead, they would be more likely to seek suitable den sites in less-disturbed areas, as suggested by Amstrup (1993).

The effects of disturbance in the operational phase are unlikely with required mitigation in place, although the magnitude may reach minor levels in the future with increasing terrestrial presence of bears in late summer and autumn. Such disturbance would most likely result in short-term behavioral alteration rather than negative population-level effects.

Injury and Mortality Effects

The same effects described for the Drilling and Construction phases would be of concern during the Operations phase of the Project, although the frequency of encounters probably would be lower due to the lower levels of human activity. Nevertheless, the attraction of polar bears to facilities and attendant problems may increase through the operational life of the Project as prey availability may decline due to changes in sea-ice cover and as more bears become stranded onshore during the open water season due to the receding sea ice, leading to increased use of coastal travel routes past the Project facilities. It is expected that the frequency of this use of terrestrial habitats will continue to increase in the future, which increases the potential for conflict and mortality due to polar bear attraction and encounters.

Overall, however, it is likely that the risk of injury and mortality probably will remain negligible due to the demonstrated effectiveness of the mitigative measures that will be required under the ITR/LOA process. Given the current and predicted declining status of the SBS stock, it is imperative that all possible measures be taken to avoid injury or mortality.

4.2.7.3 Yellow-billed Loon

Drilling and Construction

Yellow-billed loons are uncommon in the terrestrial (onshore) habitats of the Project area but do occur in nearshore waters between the mainland coast and the barrier islands (see Section 3.2.7). These nearshore waters would be used during the Drilling and Construction phases for ice roads and during the Construction phase for marine transportation of Project facility modules to the Project site by barge. Offshore ice roads are likely to melt before the arrival of Yellow-billed Loons in the nearshore waters, thus they would have no effect on loons. All other Drilling phase activities taking place in winter, when loons are not present in the Project area also would have no effect on this species.

Unlike offshore ice roads, which would melt before the use of nearshore waters by loons, onshore ice roads have the potential for some adverse effects on Yellow-billed Loons, should they be present in the area affected by the ice roads. Earnst (2004) suggests two ways that ice roads on land could negatively affect Yellow-billed Loons: 1) ice roads constructed across breeding lakes may delay ice melt, which delays onset of breeding by loons and could reduce nesting success and productivity, and 2) ice roads may increase lake-ice depth, which decreases the open water area under the ice necessary for overwintering fish populations that are food for breeding loons in the following summer. An additional effect of ice road construction is the withdrawal of water from lakes to construct the ice roads. If those withdrawal lakes are used by nesting loons, the drawdown of water could affect fish populations or lower the lake surface-water level relative to the shoreline, making access to shoreline nesting habitats difficult for loons. Because few Yellow-billed Loons appear to use terrestrial habitats in the Project area, and the effects of ice roads are short-term, the likelihood of these negative effects of onshore ice roads is minor. Insufficient data are available to assess the number of Yellow-billed Loons that would be affected by draw-down in water source lakes for the Project.

Habitat Loss and Alteration

Because exploratory drilling activities would take place from existing gravel pads and ice pads, no gravel placement would take place during the Drilling phase. During the Construction phase, however, gravel would be placed on tundra habitats during expansion of the exploration pad to create the Central Pad, for the airstrip, for a road connecting the Central Pad to the airstrip and gravel mine, and, possibly for roads to the East and West pads. Gravel placement results in both direct loss of habitats covered by gravel and indirect effects on adjacent habitats (see discussion above for Vegetation and Birds for types of effects). A secondary effect of gravel pad and road development is their associated human activities including vehicular traffic, infrastructure, maintenance activities, vehicle and facility noise, and human pedestrians. Earnst (2004) indicated that one of the primary detrimental effects of oil field development on Yellow-billed Loons would be direct and indirect habitat loss, through gravel placement for roads, drilling and facility pads, and airstrips (direct loss) or by displacement from habitats by construction and operation of facilities near nesting or brood-rearing lakes. Based on the relatively low abundance of Yellow-billed Loons in the Project area, and apparent lack of suitable lakes (large lakes with resident fish populations) for breeding Yellow-billed Loons in the Project area, the overall effects of gravel pad placement during Construction phase activities on Yellow-billed Loons are likely to be none to minor.

The effects of the sealift landing structures on habitat loss and alteration were discussed in the Section 4.2.4. Birds, and the potential effects on loons would be similar to those described for other birds. As Yellow-billed Loons primarily dive for their food when in nearshore waters they would be affected by any changes in the benthic prey populations from dredging. These effects are likely to be temporary, affect limited habitats, and would not affect loons after the initial construction season, thus this effect is considered to be minor for Yellow-billed Loons.

Disturbance Effects

Yellow-billed Loons using the nearshore marine waters during the Construction phase may be disturbed by movements of marine vessels and barges transporting materials and facility modules to the Project area from the sealift off-loading facility located in or near the barrier islands. No data are available concerning the effects of vessels on Yellow-billed Loons (Earnst 2004), but if they react similarly to other waterfowl when approached by vessels, they would tend to move away either by swimming or by taking flight if the disturbance is severe. Loons also may dive in response to disturbance, but whether this strategy is commonly used in marine waters is unknown. Overall, the negative effects on loons from disturbance in nearshore waters is likely to be minor, given the local scale of these disturbances, their short duration, the low number of loons likely to be affected by such disturbances, and their ability to move away from any disturbing source.

Mortality Effects

Yellow-billed Loons using the nearshore marine waters during the Construction phase may be at risk for collision with marine vessels or with the barge offloading system (permanent mooring dolphins and annually constructed barge-bridge. As discussed under Section 4.2.4 Birds, the grounded barge-bridge extends above the sea surface just offshore from the Central Pad and, therefore, could pose a collision hazard for Yellow-billed Loons flying at low altitudes along the coast. Although the limited extension of these structures (1,200 feet [366 meters]) into the nearshore waters reduces this potential somewhat, the small risk of collision still merits the conclusion of minor effect on loons.

Erected during the Construction phase, the communication towers for the Project would present a collision hazard for loons. One communication tower would be located on the Central Pad and would be 160–200 feet tall (49–61 meters). The design of this tower has not been determined, but both guywires and trestle structures present collision hazards. An additional communication tower would be located either at Badami or at the ExxonMobil pad in Deadhorse. No design details are available for the secondary tower. The Badami site, however, is likely to present greater avian collision hazard than would the Deadhorse site because of its proximity to coastal migration paths. Although these towers likely would result in minor effects on loons, some collisions and mortality may occur, particularly during migration when large numbers of birds move along the coast and weather and visibility often are poor. Data on the flight altitudes and flight paths and numbers of migrating Yellow-billed Loons are lacking for the Central Pad site, so the magnitude of hazard cannot adequately be assessed. Collision hazards for birds are discussed more fully for all bird species under Operations.

<u>Operations</u>

Some limited use of ice roads to access the Project area may occur during the Operations phase (see discussion of the effects of ice roads on Yellow-billed Loons above in Section 4.2.7.2, Drilling and Construction).

Habitat Loss and Alteration

Snow dumps and snow drifts are unlikely to affect Yellow-billed Loons, unless they are placed on nesting lakes or near nesting habitats. If snow accumulates, or is placed, in habitats used by loons, then those habitats would be unavailable for use by loons until the snow melts in early summer, which could compromise nesting, if nest sites or nesting lakes are affected. Identifying nesting lakes and requiring avoidance of those known nesting locations would eliminate the potential for adverse effects from this Project activity. Given the low likelihood of nesting loons in areas affected by snow dumps or drifts, this effect of this change in habitats for loons is considered to be none.

Disturbance Effects

Disturbance of Yellow-billed Loons during the Operations phase for the Project likely would be less than during the Construction phase, because the number of vessel movements in the nearshore waters of Lion Bay to support the Project would be reduced. The lack of reported nesting of Yellow-billed Loons in the Project area also reduces the likelihood of disturbance by facility operations, noise, or vehicle and aircraft traffic on nesting loons. Any Operations phase activities, such as oil spill drills, in the nearshore waters could disturb Yellow-billed Loons when they are present in summer. North (1994) described Yellow-billed Loons as being sensitive to disturbance at nests and roosting sites, but reported only one documented case of chick loss (to a Glaucous Gull) following a human disturbance at a nest (North and Ryan 1988). Recent studies of Yellow-billed Loons on the Colville River Delta and in the National Petroleum Reserve – Alaska (NPR-A), which involved helicopters landing near nests and biologists approaching on foot, found that most Yellow-billed Loons did not leave nests because of the helicopter disturbance, but did leave when humans approached nests (Johnson et al. 2009). The distance at which loons left the nest varied among individuals, but the general behavioral response was to swim away from the nest and return once the humans had left. Disturbance of Yellow-billed Loons by Operations phase activities is considered to be none to minor because of the low likelihood that loons would be using habitats near Project in-field infrastructure. Disturbance of Yellow-billed Loons by offshore activities could increase to moderate, depending upon the timing of activities, their duration (long duration would have greater effects), and the intensity of the activity (e.g., number of vessels and types of movements [i.e., direct travel is less disturbing than circling]).

Mortality Effects

Oil and Contaminant Spills or Leaks: Oil spills and other contaminant spills and leaks that entered habitats used by Yellow-billed Loons would be severely detrimental to loons because oiling of plumage can quickly result in death for aquatic birds through ingestion while preening or hypothermia after loss of insulation from oiled feathers. Oil spills on land near breeding lakes would negatively affect breeding adults and young, if present. Offshore oil spills in Lion Bay during the summer and fall months would also likely negatively affect Yellow-billed Loons using these nearshore waters. Earnst (2004) suggests that the description of Yellow-billed Loons as being at low risk from a marine oil spill may be accurate at the population level, but that risk increases for individuals using marine waters near nesting areas or, as in the case of Lion Bay, where some numbers of non-breeding birds occur annually. Yellow-billed Loons also may be vulnerable to oil spills in nearshore waters during spring staging, when open water leads are used along the Beaufort Sea coast (Alexander et al. 1997; Earnst 2004). For onshore activities during the Operations phase, the overall effect of oil and other contaminant leaks on Yellow-billed Loons is minor, given the apparent lack of use of habitats in the Project area, but the overall effect for loons in the nearshore waters rises to a moderate to major effect depending on the seasonal timing, spill type and quantity, and geographic scope of the spill. Measures used to avoid and minimize potential spills are discussed in Section 4.4.

Collisions with Vehicles or Infrastructure: Direct mortality of Yellow-billed Loons during the Operations phase could occur from collisions by flying loons with overhead power lines, facilities (flaring towers and buildings), vehicles, or other structures (communication towers, the sealift landing structure). These types of collisions are most likely during spring or fall migration when birds may be traversing the area and when visibility is limited (fog, snow storms, or at night). Structures located in the nearshore (e.g., the barge landing system) or along the coast (e.g., on the Central, East, and West pads) are likely to cause the most problems, as loons tend to migrate along the shore or in the nearshore waters (North 1994). The overall effect of increased mortality from collisions on Yellow-billed Loons in the Project area is considered to be minor, given the local scale for this effect and the low likelihood of mortalities causing a measurable population-level effect. Mitigation measures that can reduce potential bird collisions were described previously in Section 4.2.4.3.

Changes in Predator Populations: As discussed in Section 4.2.4 Birds, predator populations have apparently increased in developed oil fields, such as the Prudhoe Bay and Kuparuk oil fields, primarily because of increased availability of anthropogenic foods, creation of artificial nesting sites or denning sites, and attraction of predators to human facilities (Day 1998). Yellow-billed Loons are susceptible to predators during nesting, when incubating adults and eggs are most accessible to predators. Earnst (2004) identified the increase in nest predators (i.e., predators taking eggs) as having an important negative effect on Yellow-billed Loon productivity, because predation is the primary cause of egg loss and contributes to some proportion of chick mortality. Time-lapse cameras used to observe nesting Yellow-billed Loons on the North Slope have documented egg predation by red fox, grizzly bear, and wolverine (Johnson et al. 2009; Johnson ND). Reported incidences of predation on adult Yellow-billed Loons are rare (North 1994). Unless Yellow-billed Loons are found to be nesting in the Project area, the overall effect of increased predator populations on Yellow-billed Loons in the area is considered to be none to minor as most use of the area is by adults in nearshore waters, where terrestrial predators are not a threat. Current oil field practices on waste-handling and worker education would reduce the attraction of predators to the Project area and reduce this potential source of increased mortality for loons.

4.2.7.4 Spectacled Eider

Spectacled Eiders are the subject of 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) related 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. Because of their protected status under the ESA, consultation with the USFWS is usually required for projects on the North Slope. The USFWS has developed preliminary protection guidelines for new developments within the breeding range of the Spectacled Eider:

- Prohibiting high-noise facilities, such as gathering centers and airports, within 0.6 mile (1 kilometer) of nest sites;
- Prohibiting facilities within 0.1 mile (0.06 kilometer) of nest sites; and
- Maintaining adequate access for birds to move from nest sites to brood-rearing areas.

Adherence to these guidelines during Project development would reduce the potential for adverse effects to the species.

Drilling and Construction

The effects of the initial Drilling phase (before the onset of construction) at the Project area on Spectacled Eiders would be limited primarily to potential temporary loss of habitats in the summer, following use of ice roads to access the field and any ice pads used to support drilling activities, as the ice is not likely to melt before the onset of nesting by eiders in mid-June. Disturbance associated with drilling during winter would not affect Spectacled Eiders, as they do not occur in the Project area in winter.

Habitat Loss and Alteration

No gravel placement is planned for the Drilling phase, as drilling would occur from existing gravel pads and ice pads. During the Construction phase, gravel placement would result in the long-term loss of 11.9 acres (0.05 square kilometers) of the most 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 (Anderson et al. 2009; Johnson et al. 2009). The direct loss of habitats because of gravel placement for the airstrip, roads, and pad(s) could have effects on Spectacled Eiders because they prefer habitats in drained lake basins and wet coastal tundra for nesting and brood-rearing. Secondary effects of gravel placement, such as impoundments, gravel and dust fallout, and thermokarst may also affect eiders (see discussion under Section 4.2.4, Birds). Spectacled Eiders have been shown to readily use impoundments in the Prudhoe Bay area (Warnock and Troy 1992) and are not expected to suffer adverse effects should small areas of surface hydrology be changed because of ponding. Similarly, negative effects on Spectacled Eider habitats from snow drifts, and other temporary changes to habitats resulting from Point Thomson Drilling and Construction activities are expected to be minor. Although Spectacled Eiders occasionally could use some other vegetation types in the Point Thomson area, water bodies and aquatic habitat types are most important to eiders during the breeding season. Habitat loss and alteration associated with gravel placement for the Project is expected to have a minor effect on Spectacled Eiders given the limited number of eiders known to use the area, the lack of evidence for extensive nesting by eiders in the Point Thomson area, and the limited acreage affected by gravel placement during the Drilling and Construction phases.

Disturbance Effects

Most activities during the Construction phase would occur in winter (January–April) and thus would have no potential for disturbing Spectacled Eiders, which do not arrive on the coastal plain until late May or early June. Behavioral disturbance of birds using habitats near roads and pads, and the types of potential effects, are discussed in detail in Section 4.2.4 Birds and similar responses are likely for Spectacled Eiders using habitats near any construction activities occurring during summer. Indirect loss of habitat because of disturbance could occur near vehicles or drilling equipment generating noise in the Project area. Spectacled Eiders were shown to shift their distribution away from the Central Compressor Plant in the Prudhoe Bay oil field, presumably because of disturbance by the increased noise output when the facility was expanded (Anderson et al. 1992). Although Drilling and Construction phases would result in activities that could cause disturbance effects to Spectacled Eiders, the scheduling of most of these activities during winter, and the relative scarcity of Spectacled Eiders in the Project area, is expected to limit any potential population-level effects from disturbance on eider behavior, productivity, or disturbance-related displacement (indirect habitat loss). Thus the overall effect of these disturbances is considered to be minor.

Some disturbance of Spectacled Eiders might result from helicopter and fixed-wing aircraft flights during both summer construction 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). A recent study on the Colville River Delta of the effects of construction and operation of a remote drilling site and airstrip found that Spectacled Eiders showed little evidence of displacement or changes in habitat use or breeding productivity near the drill site during three years of construction and operations of the site (Johnson et al. 2008). Spectacled Eiders are not frequently disturbed by vehicular traffic on oil field roads, as long as vehicles do not stop near eiders (Anderson 2009). In general, the relative scarcity of Spectacled Eiders in the Project area would limit any potential population-level effects from disturbance or indirect habitat loss by ground vehicles or aircraft overflights, thus the overall effect would be minor.

Mortality Effects

Spectacled Eiders likely are at low risk for collisions with marine vessels or with the barge offloading system (permanent mooring dolphins and annually constructed barge-bridge) because eiders typically migrate well offshore, in the region of the barrier islands. Similarly, collision risk with onshore infrastructure likely is low but some collisions and mortality could occur from movements of local nesting birds during summer and during migration when weather and visibility often are poor. Collision hazards are discussed more fully for all bird species under Section 4.2.4.3, Operations.

Operations

Some limited use of ice roads to access the Project area may occur during the Operations phase (see discussion of the effects of ice roads on Spectacled Eiders above in Section 4.2.7.3, Drilling and Construction).

Habitat Loss and Alteration

Snow dumps and snow drifts are unlikely to affect Spectacled Eiders, unless they are placed on lakes or ponds used by nesting eiders or on or near nesting habitats. If snow accumulates or is placed in habitats that could be potentially used by nesting eiders, then those habitats would be unavailable for use until the snow melts in early summer, essentially eliminating nesting in that area for that year. Identifying and avoiding areas where Spectacled Eiders are known to nest would eliminate the potential for adverse effects from this operations activity. This activity could have a minor to moderate effect on Spectacled Eiders if nesting habitats were covered by snow, with the moderate effect occurring if the loss of nesting habitats occurred in more than one year.

Disturbance Effects

Reactions of Spectacled Eiders to infield disturbances (vehicles, aircraft, facility noise) during the Operations phase of the Project would be similar to those described above for the Drilling and Construction phases. The relative effect of disturbance may actually be somewhat less during the Operations phase, as the amount of vehicular and aircraft traffic would be expected to decline once the field begins operating, thus the overall effect is considered to be none (if no eiders are present) to minor.

Mortality Effects

Oil and Contaminant Spills or Leaks: As with other birds, the effects of oil and other contaminants on Spectacled Eiders depends on the type of contaminant spilled, the season the spill occurs, where the spill occurs (habitat types), and the number of birds present that could be affected. Because most Spectacled Eiders occur to the west of the main production area at the Project site, effects on Spectacled Eiders related to possible spills would most likely be from the pipeline rather than from contaminants found on the drilling and production pads. The likelihood of a pipeline spill affecting Spectacled Eiders is considered to be low; however, given the relative distribution and abundance of this species along the pipeline and thus the overall effect is considered to be minor.

Collisions with Vehicles or Infrastructure: Oil field infrastructure in the Project area could cause some mortality of Spectacled Eiders during poor weather conditions if low-flying eiders collided with elevated structures, such as module buildings, flare stacks, or communications towers, or with the barge landing system located just offshore from the Central Pad. The potential for such adverse effects appears to be limited, however, because the Project area is at the eastern end of this species range on the ACP and movements of large numbers of Spectacled Eiders past the Project site are unlikely, thus the overall effect is considered to be minor.

Increasing Predation: Increased predation levels because of the attraction of predators (by human activities and wastes) to the Project area could affect small numbers of breeding Spectacled Eiders. The number of breeding pairs that have been observed in the Project region in June is low (less than five pairs) and only one brood of Spectacled Eiders has ever been reported in the area, near Point Sweeny about 2 miles (3.2 kilometers) east of the proposed West Pad. Therefore, increased predation is unlikely to have a population-level effect on Spectacled Eiders and the overall effect is considered to be minor.

4.3 HUMAN RESOURCES

4.3.1 Socioeconomics

Effects of the Project on the socioeconomic characteristics and cultural resources of the area can occur through a reduction or an increase in population, contribution to economy and income, changes in land use and management (include traditional use of lands by North Slope residents), changes to subsistence activities and harvest levels, changes to recreational levels and experience, or changes to visual resources. The consequences of disruption or displacement, restriction, and destruction are applicable to land use and management, subsistence, recreation, and visual and cultural resources. Unlike other sections of this document, socioeconomics does not easily lend itself to an assessment by drilling, construction, and employment. Information is not currently available to breakout drilling and construction activities, which will occur at the same time and include a workforce that is already present at the drilling site. The situation is similar for indirect employment and expenditures on goods and services. Additions to NSB property tax will likely transition over both construction and operations phases. As Project estimates are finalized, more detailed information is likely to be available during formal NEPA compliance.

4.3.1.1 Population

The Project is unlikely to significantly alter the population base of the local communities of the NSB or the State of Alaska (state). The Project is relatively small, requiring 75 personnel for operations, and 450 during the temporary construction phase; the majority of these workers will not be residents of the NSB, but may be residents of Alaska. Workers will be housed on-site at Point Thomson facilities for both construction and operations phases, avoiding the potential for significant direct effects on the relatively small village communities in the area. Additionally, this physical separation of workers from established local communities would also render it unlikely that incoming non-resident construction workers will settle in the NSB.

The addition of non-Alaskan Point Thomson personnel and their families would be a relatively minor addition to the NSB population of 6,700 (2008 state estimate), and to the population of the state. However, employment opportunities for local NSB residents could provide income that supports families of resident workers staying in their communities. This would be expected to mirror the current pattern of such local employment, although ExxonMobil will work with local communities to facilitate resident hire. Therefore, the overall direct population effect is expected to be minor.

4.3.1.2 Employment and Income

Direct Project Employment

A direct positive economic effect from the Project will be the creation of new jobs for construction, operations, and Project support. 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 generate 75 long-term positions for operating and maintaining the facility. Oil companies operating on the North Slope have historically made a commitment to hire Alaskan resident workers on the North Slope and within Alaska. Employment created by the Project would have a moderate positive effect.

Regarding long-term jobs in operations, local residents' need for seasonal flexibility to pursue subsistence activities and other factors may reduce the attractiveness of oil field operations employment when other jobs (for example, at the NSB) with greater flexibility are available. The historic lack of employment flexibility and isolation from families during work rotation has hindered village resident employment by the oil industry, even though recruitment efforts are made and training programs are available.

Although the employment history of local Kaktovik, Nuiqsut, and other North Slope residents has not involved extensive oil field operations experience, North Slope residents have expressed interest in training for full-time, year-round operation and maintenance jobs at Point Thomson. The employment of North Slope residents in these positions, even in small numbers, could have a positive and potentially moderate effect on the local village economies.

Short-term construction and drilling positions, being more seasonal in nature, provide greater flexibility with regard to North Slope residents' participation in subsistence activities. In particular, positions that take place during the winter phase of construction provide great flexibility during a period of low subsistence activity. There are local (village corporation subsidiary) firms specializing in the construction of ice roads which could benefit from the Project. In addition, many of the contractors hired for the 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 may provide indirect benefit to the wider Native community, as well as to individual workers.

Indirect Employment within the State of Alaska

In 2007 (according to the Information Insights and McDowell Group study [McDowell Group 2008]) across all sectors of the Alaska economy, the oil and gas industry indirectly accounted for $4 billion in value added and $6.6 billion in total output in 2007. This does not include values added or output associated with expenditure of taxes and royalties paid by the oil industry to state government. An Oil and Gas Policy Council report estimated that every $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 1995 Oil and Gas Policy Council report, the 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 Project Development Case. In addition, the state will benefit directly from capital expenditures (associated with purchase of services and materials) in the economy, leading to the creation of a moderate increase in indirect employment.

4.3.1.3 Public Revenue and Expenditures

Oil and gas revenues support a variety of expenditures and have allowed the NSB to pursue significant capital improvement projects and also support government employment, local health and social services and cultural initiatives. The increase in the NSB tax base through the addition of the Point Thomson facility will also indirectly benefit employment in the region, as the NSB employs about 60 percent of the NSB's working population.

Over the estimated life of the Project, additional benefits will accrue to the state through the state's share of the federal royalty, income tax, and ad valorem tax, some of which will also accrue to the NSB. This benefit will occur at a time when state and NSB revenue, heavily dependent on production from the large North Slope oil fields, could be declining. The Project by itself will not offset these declines, but it could help mitigate the severity of any decline. The Project will add approximately $1 billion to the NSB and state taxable property, resulting in a moderate increase.

Other potential socioeconomic effects from the Project on its own are likely to be minimal, and so are perhaps better discussed in terms of the potential cumulative effects to which they will contribute. These are discussed in Chapter 6. Socioeconomic effects are summarized in Table 4-27.

TABLE 4-27: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON SOCIOECONOMICS

Socioeconomic Subcategory	Direct Effect	Indirect Effect
Population	None	Minor
Direct Project Employment	Moderate (positive)	Moderate (positive)
Indirect Employment within the State of Alaska	Moderate (positive)	Moderate (positive)
Public Revenue and Expenditures	Moderate (positive)	Moderate (positive)

4.3.2 Cultural Resources

The results of a number of cultural resources reconnaissance surveys of the Project identified 21 sites that are listed on the Alaska Heritage Resources Survey (AHRS) archaeological database. Six of these sites are also listed on the NSB's Traditional Land Use Inventory (TLUI) database (see Section 3.3.3). The known sites in the Project area are primarily located along the Beaufort Sea coastline. A cultural resource management plan currently being developed with the input of the NSB's Inupiat History, Language, and Culture (IHLC) Division, whose mission is to ensure that cultural issues are given appropriate consideration during planning processes, will further clarify the specific cultural resource sensitivity zones in the Project area.

As Lobdell and Lobdell (2000) 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 overall archaeological sensitivity of the Project area. Effects on any identified or unidentified cultural resources of the area would be either through destruction and/or disturbance of the site during construction activities, or through disturbance of artifacts by unauthorized visitors. Destruction could be defined as the physical obliteration of the site, while disturbance could involve removal of the artifacts or other effects to the integrity of site features or artifacts. With effective protective measures in place, disturbance and/or destruction of known cultural resources because of either winter or summer construction efforts is unlikely and would be negligible.

Archaeological inventory of the Project footprint did not result in the identification of surface sites or indications of buried cultural sites within the current Project footprint. Some areas of low to moderate sensitivity, however, such as creek banks, have not been thoroughly surveyed for cultural resources and may contain small and difficult-to-detect sites such as flake scatters or isolated artifacts.

Unidentified buried archaeological sites may be inadvertently affected through Project-related gravel excavation at the proposed gravel mine, or during airstrip or gas pipeline construction. However, given the environs elsewhere within the Project area, and given the thorough survey coverage of potentially affected areas, direct effects on cultural resource sites are regarded as highly unlikely and would be negligible. Currently identified archaeological sites are limited in area and well known. There should be no direct adverse changes to the physical remains present at these sites, because they can easily be avoided. Mitigation measures of monitored site buffer zones and personnel briefings should adequately counter any potential effects during winter and summer construction activities (see Chapter 5).

Systematic surveys, including subsurface testing for deeply buried cultural resource sites in the Project area, are not likely to produce many archaeological resources and might create unintended changes to fragile permafrost. If cultural resources are discovered during construction (airstrip/road construction, gravel mining, or gas pipeline construction), any work that may damage these resources will be halted, and the State Historic Preservation Officer and the IHLC Division will be contacted. Following consultation, a decision will be made to avoid, protect, or recover the resource, using appropriate scientific methods.

Indirect effects to cultural resources include destruction or disturbance to cultural resources and the heritage resource record from unauthorized visitation, increased pedestrian traffic, looting, or contamination of cultural resources sites. Indirect effects may occur to sites not directly in the path or footprint of a project, but in close enough proximity to be disturbed by the aforementioned activities. The effects could occur either during construction or operations activities. To mitigate any potential indirect effects, all Project personnel will receive training about the importance of cultural resources and will be instructed to avoid these sites. The training would include a discussion of the penalties for disturbance to any cultural site. The lack of a permanent access road along the pipeline route will restrict year-round access to the Project area and aid in mitigating indirect effects. Mitigation would result in reducing potential effects to minor. Anticipated effects on cultural resources are summarized in Table 4-28.

TABLE 4-28: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON CULTURAL RESOURCES

Resource	Direct Effect	Indirect Effect
Cultural Resources	None	Minor

4.3.3 Subsistence and Traditional Land Use

As discussed in Section 3.3.3, Alaska National Interest Lands Conservation Act (ANILCA) Section 810 requires a formal determination of whether a proposed action on federal lands in Alaska (or requiring federal permits and action by federal agencies) will affect subsistence uses or not. If the proposed action requires a NEPA process (environmental assessment [EA] or EIS) as well, the ANILCA determination process will in most cases be incorporated into the NEPA process and must be included in the resulting documents. Effects on subsistence and traditional land use can be caused by direct or indirect actions of the Project that result in decreased subsistence use opportunities or a displacement or reduction in subsistence animals. The three categories of potential effects on subsistence and traditional land use defined by ANILCA are:

- Changes in the abundance or distribution of subsistence resources.
- Changes in the access to subsistence resources, which includes:
    - Changes in human behavior, which can include restricting access to a subsistence resource either by regulation or physical impediments;
    - Disruption of subsistence activities, resulting in a reduced harvest;
    - Decreased use of an area or resource due to the perception that the subsistence experience has been affected or that the resource has been tainted;
- Changes (increase) in competition for subsistence resources.

If the proposed action may “significantly restrict” subsistence uses in terms of abundance and distribution of resources, access to resources, or competition for resources, ANILCA requires the following actions:

- Notice to the appropriate State agency and the appropriate local committees and regional councils established by ANILCA Section 805 (as well as tribal entities and communities likely to be affected);
- After proper notice, the conduct of hearings in the vicinity of the area involved (the number of hearing locations dependent on the size of the area involved and the number of communities potentially affect by the proposed action);

After such hearings for the collection of testimony and additional information on subsistence uses in the Project area and potential effects of the proposed action, a formal determination that either the proposed action will not take place or is modified so that the restrictions do not occur, or that the significant restriction is necessary and that the proposed action meets three additional criteria:

- It is consistent with sound management practices for the utilization of public lands,
- It involves the minimal amount of public lands necessary to accomplish the proposed action, and
- Reasonable steps have and will be taken to minimize adverse impacts upon subsistence uses and resources (ANILCA Section 810).

Effects on subsistence game, such as polar bear, caribou, and fish, are discussed in Sections 4.2.3 through 4.2.7. In some cases, disturbance to fish and wildlife resources in the Project area used for subsistence will not have a local or population level effect on the resource disturbed, but may result in changes in their behavior and displacement from the Project area, impacting subsistence harvest activities. This Environmental Report (ER) will not include a draft ANILCA determination, leaving that for the formal draft EIS. It is assumed that ANILCA hearings will be required, as potentially significant effects on subsistence uses are possible from the proposed action (primarily upon caribou and associated uses in the Brownlow Point area, and potential disturbance of caribou migration). These should be minimized through appropriate mitigation measures, which will require an ongoing consultation/communication process with Kaktovik stakeholders. ANILCA hearings will be one step in the formal documentation of this process.

4.3.3.1 Drilling

The main effects on subsistence use at Point Thomson related to drilling may be direct effects on the subsistence resources, changes in animal (or hunter) behavior, increased limitations on access to subsistence resources, and general disturbance (noise, equipment).

The subsistence uses most likely to be affected by the Project are caribou hunting (and associated activities) and the fall bowhead whale hunt. Seals, fish, terrestrial mammals other than caribou, and birds are also sometimes taken from or near the Project area, but usually only in conjunction with caribou hunting. Residents of Kaktovik generally use the Point Thomson area much more frequently than the residents of Nuiqsut.

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 anticipated. There is a possibility that barging activities in support of drilling could disturb bowhead whales during migration and potentially affect their availability for subsistence harvest. ExxonMobil has signed a CAA with the Alaska Eskimo Whaling Commission (AEWC), restricting barge traffic as ice and other conditions allow, avoiding the subsistence bowhead whale hunt season. Therefore potential direct and indirect effects on subsistence whaling are expected to be minor.

While the Point Thomson area falls within the boundaries of the possible total extent of Nuiqsut and Kaktovik whaling areas, it is well removed from the “core” whaling areas used by either of these communities. All documented strikes by both communities, except for the two whales taken by Nuiqsut in 1973 and 1982, took place within the two communities’ core whaling areas. Those two Nuiqsut strikes occurred before the current establishment of Cross Island as a logistical base for Nuiqsut whaling (Galginaitis 2009), during the era when Nuiqsut crews commonly used a number of barrier islands, some east of Cross Island, as temporary whaling camps. While it is not beyond the realm of possibility that Nuiqsut whalers could whale east of Bullen Point, the towing distance from Cross Island is nearly 30 miles, necessitating either a very long tow or butchering a whale at an alternate site. Similarly, it is unlikely for Kaktovik whalers to strike a whale east of the Okpilak Point/Hulahula River area. As described above, the core Nuiqsut bowhead harvest area centers on Cross Island, well to the west (Figures 3-42 and 3-44). The Kaktovik core area falls between Camden Bay and Griffin Point well to the east of the Project area (Figure 3-38).

Drilling activities are anticipated to have minor effects on diadromous, freshwater, or marine fish (Section 4.2.3). 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 in most years. In those years when caribou harvest in this location is greater than “normal” there may also be associated increased fishing activity.

The subsistence use of terrestrial mammals in the Project area is limited but potentially significant in terms of contribution to harvest totals, and mostly focused on caribou, primarily due to its distance from Nuiqsut and Kaktovik. There is a historical summer caribou hunting site for the Kaktovik village adjacent to the Project area, as discussed above; its use depends annual patterns in caribou availability. Hunters access the Point Thomson area by boat, harvesting caribou that use the coastal area for insect relief. This site can be quite important in years when caribou are not available at other sites – for one of the years (1982-83) with documented harvest locations this site accounted for 37 percent of Kaktovik’s caribou harvest, although more typically 2–10 percent of the community’s caribou would be taken at this location (Pederson and Coffing 1984; Coffing and Pedersen 1985; Pedersen 1990).

The potential for Project effects on terrestrial mammals other than caribou is primarily limited to the immediate vicinity of the Project area, as the Project is not planning to build overland transportation routes and pipelines will be elevated to a minimum height of 7 feet to allow passage by caribou. During the summer, transportation will be via marine vessels or aircraft. Thus most potential disturbance of terrestrial mammals due to summer and fall construction should be limited to the immediate locale of the Project and, given the present use pattern of local Inupiat hunters, should be minor, with some relatively simple mitigation measures. ExxonMobil has already instituted a regular consultation process with Kaktovik stakeholders and will design the Project and operational practices to address their concerns so that they can continue their subsistence activities at Brownlow Point and the associated area. This may involve discussions on such things as aircraft flight schedules, overflight elevations, and periods of operation or shutdown (timing).

Another concern to be addressed for all phases of the Project is the avoidance of affecting or deflecting the caribou migration(s) and calving that may occur in or near the area. Caribou migrations and calving vary from year to year, and some animals from the CAH (and to a lesser extent, some animals from the PH) may use the Project area. Inupiat hunters consistently stress that the first animals in any migration are especially critical as leaders for the bulk of the migration that is following them and that they must not be disturbed. If they are hunted or otherwise disturbed, the rest of the animals may well go somewhere else and thus not be readily available to the hunters. Thus it will be critical to design mitigation measures that minimize any possibility of Project associated activities spooking caribou at the start of migration periods (visual and noise measures). Pipeline height standards address one potential constrain or effect upon caribou migration, but Project behavioral policies and operating (or shutdown) periods will also be critical, and can only be adequately designed in collaborative consultation with the potentially affected parties from Kaktovik.

It can be expected that adequate mitigation measures for caribou uses will also address any concerns raised about other subsistence uses associated with the site such as camping, fishing, and visiting traditionally used lands, resulting in minor effects.

4.3.3.2 Construction

The majority of on-site construction activities at the Project area will take place during February–May over two to three seasons. However, activities will occur during the winter, including construction and maintenance of ice roads, and during the summer on established gravel pads. Polar bears and ringed seals are the only subsistence animals expected to be within the Project area during winter construction. Nuiqsut and Kaktovik hunters generally do not venture as far west as the Point Thomson area in the winter in order to conduct their traditional subsistence activities. Winter construction activities occur during a season in which subsistence use of the Project area is low to none, and will likely be negligible.

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 this subsistence use will likely be negligible.

Some localized disturbance of seals is possible due to noise associated with winter construction activities, but overall population changes 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 Section 3.3.3, 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.

Whales will not be present in the Project area during winter construction (Section 3.2.5). Similarly, potential winter construction effects on fish are judged to be negligible (Section 3.2.3), and subsistence use of the area for fishing is infrequent and limited to summer.

Subsistence hunters in the area tend to rely on caribou hunted closer to the village for their winter protein (see Section 3.3.3). As indicated in previous reports (USACE 1999) and discussed above, the limited available caribou harvest locational information indicates that the area around the Project has not been used regularly by local villagers as a winter caribou harvest area Camden Bay, to the east of the Project area, is a regularly used winter caribou harvest location for Kaktovik hunters.

Winter construction effects, including gravel extraction, on terrestrial subsistence resources and their use for subsistence are expected to be minimal. Use of the Project area by subsistence hunters in general is low and practically non-existent in winter, when trapping and hunting of fur bearers occurs closer to the communities (see Section 3.3.3). As a result, onshore gravel extraction, placement of fill, and winter pipeline construction are not expected to reduce, restrict, or disrupt subsistence activities and effects will likely be negligible.

As the construction of the pipeline and East and West Pads takes place, an increasing amount of the coastline in the Point Thomson area would be affected by linear facilities. This raises potential conflicts between subsistence access and safe operation of facilities, particularly given the possibility of hunting caribou from the shoreline. ExxonMobil will need to work with hunters from Kaktovik (and Nuiqsut if they wish to participate) to develop a subsistence access plan that maintains traditional access to the area and outline safety procedures to protect personnel and facilities. These measures will also need to address concerns about effects on caribou migration (deflection). Depending on the success of mitigation, potential effects would be minor to moderate.

In sum, the effects of the construction phase on subsistence uses will be primarily from direct effects upon the abundance and distribution of subsistence resources. The potential for such effects has been addressed in the biological discussions above.

4.3.3.3 Operations

As discussed in the two previous sections, the Point Thomson area is generally less-utilized on a regular basis for subsistence when compared to areas closer to Nuiqust or Kaktovik, and is used much more by Kaktovik hunters than Nuiqsut hunters. Summer whaling, caribou hunting and fishing activities have a much greater potential to be disrupted when compared with winter subsistence activities. Subsistence uses take place much more frequently in the summer in the Point Thomson area, primarily because there are more subsistence resources present in the area in the summer and access (and overall conditions) are better in the summer.

Noise generated during operations is expected to be less than noise produced during drilling and construction phases. Disturbance effects on local wildlife are anticipated to be minimal and not expected to affect subsistence resource population levels, resulting in minimal subsistence effects. However, it will be necessary to regularly consult with Kaktovik hunters about such potential disturbances to hunters and/or wildlife such as operation noises, traffic and dust on roads and gravel pads, the flaring of gas, aircraft noise and visual overflights, and barge traffic. All (except for barges) have been problematic for Nuiqsut hunters with regard to the development of Alpine and it's associated Satellites (BLM 2004). Also, as discussed above, caribou are especially sensitive to any sort of disturbance at the beginning stages of migration. Mitigation measures must be proactive and already in place before the anticipated period of migration, and not rely on seeing the first caribou of the migration before being implemented or operationalized. Depending on the success of mitigation, potential effects would be minor to moderate.

Competition for local subsistence resources with Project personnel is recognized as a potential consequence of the Project. In order to mitigate this, hunting by personnel in the vicinity of the Project will be prohibited and all personnel will be required to comply with applicable ADF&G sport fishing regulations.

Once production and pipeline facilities have been constructed, an increasing amount of the coastline in the Point Thomson area would be affected by linear facilities. This raises potential conflicts between subsistence access and safe operation of facilities, particularly given the possibility of hunting caribou from the shoreline. ExxonMobil will need to work with hunters from Kaktovik and Nuiqsut to develop a subsistence access plan that maintains access to the area and outlines safety procedures to protect personnel and facilities.

A pipeline spill or well blowout remains a great concern for subsistence users in the area. The effects of a spill on subsistence activities may cause displacement or mortality of resources, restrict subsistence users' access to resources, and may create the perception that the resources are "tainted" or no longer appealing due to contamination. The perception of contamination can also occur even if resources are not actually affected.

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 EIS 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 risk of a large oil spill is discussed in Section 4.4. The Project will minimize the potential for leaks and spills to the greatest extent possible to protect subsistence resources and subsistence and traditional uses.

Again, potential effects on the abundance and distribution of resources have been addressed in the biological sections of this report. It is important that these be minimized, since any effects at this level would potentially affect multiple communities (11 communities in terms of direct bowhead whale harvests, and many more because of negative effects on sharing networks).

In conclusion the direct and indirect effects to Subsistence and Traditional Land Use in the Project area range from none to minor during drilling. Moderate effects could occur during construction of the export pipeline and during operations (see Table 4-29).

TABLE 4-29: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON SUBSISTENCE AND TRADITIONAL LAND USE

Phase	Subsistence and Traditional Land Use Concern	Direct Effect	Indirect Effect
Drilling	Fish	Minor	Minor
	Marine mammals	None to Minor	None to Minor
	Caribou	Minor	Minor
Construction	Facilities	None	None
	Pipeline	Minor to Moderate	Minor to Moderate
Operations	Caribou	Minor to Moderate	Minor to Moderate
	Marine mammals	Minor to Moderate	Minor to Moderate
	Resource access	Minor to Moderate	Minor to Moderate

4.3.4 Land Ownership, Use, and Management

This section addresses the direct and indirect effects of drilling, construction, and operation activities on land ownership, land and water use, and land management. Refer to Section 3.3.4 for a description of the effected environment. Table 4-30 at the end of this section summarizes potential direct and indirect effects.

4.3.4.1 Drilling

Land Ownership

Federal Lands

For the Project, drilling activities will take place on the Central, East, and West pads, all of which are on state lands. There will be no effect on ownership of federal lands.

State Lands

The primary effects on ownership of state land consist of granting leases, ROWs, material sales, and appropriation of water. ExxonMobil is currently permitted to drill wells from the Central Pad under an approved Plan of Operations with Alaska Department of Natural Resources (ADNR). However, drilling from the East and West pads will require additional approvals before activities can commence. Direct effects of drilling on state lands will be minor, and there will be no indirect effects.

North Slope Borough Lands

For the Project, drilling activities will take place on the Central, East, and West pads, all of which are on state lands. There will be no effect on selected or owned Borough lands.

Alaska Native Corporation Lands

There are no selected or conveyed Alaska Native Corporation Lands in the Project area. For the Project, drilling activities will take place on the Central, East, and West pads, all of which are on state lands. There will be no effect on ownership of Alaska Native Corporation lands.

Alaska Native Allotments

For the Project, drilling activities will take place on the Central, East, and West Pads, all of which are on state lands. There will be no effect on ownership of Alaska Native allotments.

Land and Water Use

Industrial and Resource Development Use

The Project area has seen sporadic activity associated with oil exploration, baseline studies, and site restoration over the last 30 years. The Project does not represent a major change in land use, and direct and indirect effects would be minor.

Subsistence and Traditional Uses

Drilling activities associated with the Project are similar to those currently permitted, with the additional drilling taking place from the East and West pads. Subsistence and traditional uses primarily occur in the summer months, associated with caribou hunting and travel through the area. Primary effects on subsistence use include restriction on hunting in the immediate vicinity of drilling operations for safety reasons. However, the area affected by drilling is relatively small, and adverse effects are somewhat offset by the advantages of having a facility and personnel in the area in case assistance is needed. The overall direct and indirect effect from drilling on subsistence and traditional use is minor. For more information about potential effects on subsistence, see Section 4.3.3.

Recreation and Tourism Uses

Drilling activities associated with the Project are similar to those currently permitted, with the additional drilling taking place from the East and West Pads. Once drilling is initiated on the East Pad, activities will occur approximately 4 miles closer to the western boundary of the Refuge. Most Refuge visitor use takes place during the summer months, when there are limitations on well completion depth and drilling is not continuous. Potential drilling effects on recreation use are considered minor. For more details, see Section 4.3.6, Recreation.

Land Management and Regulations

Federal Management

For the Project, drilling activities will take place on the Central, East, and West pads, all of which are on state lands. Federal management of the Refuge will not be directly affected. However, indirect visual and noise effects associated with drilling may conflict with Refuge management objectives. These effects are considered minor, but ExxonMobil will work with USFWS to develop measures to mitigate potential Project effects on the Refuge.

State Management

Drilling on the Central, East, and West pads will likely require additional management approvals from the State of Alaska. Similarly, as part of the Project, drilling activities must be consistent with the standards of the Alaska Coastal Management Program (ACMP). Applications for authorizations and consistency reviews will take place concurrent with the NEPA compliance process. These effects are considered minor, assuming approvals are granted.

North Slope Borough Management

For the Project, drilling activities will take place on the Central, East, and West pads, all of which are on state lands. Permits and approvals for drilling activities will be required to be consistent with the enforceable policies of an approved NSB coastal management plan. In addition, drilling activities are also required to comply with BLM Regulations. Drilling activities are expected to comply with BLM requirements, with some stipulations. These effects are considered minor, assuming approvals are granted.

4.3.4.2 Construction

Land Ownership

Federal Lands

For the Project, construction activities will take place on state lands. There will be no effect on ownership of federal lands.

State Lands

The primary construction effects on ownership of state land consist of granting leases, ROWs, material sales, and appropriation of water. ExxonMobil is currently permitted to drill wells from the Central Pad under an approved Plan of Operations with ADNR. However, construction activities associated with the Project will require additional state approvals before activities can commence. Construction of the gathering and export pipelines will require approval of ROWs from the State Pipeline Coordinators office. Direct effects of construction on state lands will be minor, and there will be no indirect effects.

North Slope Borough Lands

The NSB has selected lands under its municipal entitlement within the Project area, in the vicinity of Project facilities. This selection has not yet been adjudicated, and potential effects would be minor, assuming that approval for use of the land selected is required and approved. There are no other potential construction effects on Borough-owned lands.

Alaska Native Corporation Lands

There are no selected or conveyed Alaska Native Corporation lands in the Project area. For the Project, construction activities will take place on state lands. There will be no effect on ownership of Alaska Native Corporation lands.

Alaska Native Allotment Lands

For the Project, construction activities will take place on state lands. There will be no effect on ownership of Alaska Native allotments.

Land and Water Use

Industrial Resource Development Use

Construction of the Project will represent a continuation of oil- and gas-related uses over a larger portion of the Project area, and will result in a minor to moderate increase in the intensity of use in this area.

Subsistence and Traditional Uses

Construction activities associated with the Project will represent an increase in intensity and area affected compared to those currently permitted at the Central Pad. Subsistence and traditional uses primarily occur in the summer months, associated with fishing, caribou hunting and travel through the area. Primary effects on subsistence use include restriction on hunting in the immediate vicinity of construction activities for safety reasons. The majority of construction activities will be taking place during the winter, and adverse effects are somewhat offset by the advantages of having a facility and personnel in the area in case assistance is needed. The overall effect on subsistence and traditional use is moderate during construction activities, and should be mitigated by working with hunters from Kaktovik and Nuiqsut. For more information about potential effects on subsistence, see Section 4.3.3.

Recreation and Tourism Uses

Construction activities associated with the Project will represent an increase over currently permitted drilling activities. Construction activities will occur approximately 4 miles closer to the western boundary of the Refuge, although most of those activities will occur during the winter when visitors to the Refuge are not present. Potential construction effects on recreation use are considered moderate but short term in duration. For more details, see Section 4.3.6, Recreation.

Land Management and Regulations

Federal Management

For the Project, construction activities will take place on state lands. Federal management of the Refuge will not be directly affected. However, indirect visual and noise effects associated with construction may conflict with Refuge management objectives during the period of construction. Indirect effects are expected to be minor, but ExxonMobil will work with USFWS to develop measures to mitigate potential Project effects on the Refuge.

State Management

Construction activities will take place on state lands and will likely require additional management approvals from the State of Alaska, including revised Plans of Operations, pipeline ROWs, material sales, and water appropriations. Similarly, as part of the Project, construction activities must be consistent with the standards of the ACMP. Application for authorizations and consistency reviews will take place concurrent with the NEPA compliance process, and direct effects will be minor.

Borough Management

Construction of the export pipeline will require approval of a request for rezoning an area between Point Thomson and the Badami Development. 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. Permits and approvals for construction activities will be required to be consistent with the enforceable policies of an approved NSB coastal management plan. In addition, construction activities are expected to comply with BLM requirements with some stipulations, and direct effects will be minor.

4.3.4.3 Operations

Land Ownership

Federal Lands

For the Project, operations activities will take place on state lands. There will be no effect on ownership of federal lands.

State Lands

Operation of the Project will occur on state lands, and will likely require additional state approvals before activities can commence. Direct effects of operations on state land will be minor, and there will be no indirect effects.

Borough Lands

The Borough has selected lands under its municipal entitlement within the Project area, in the vicinity of Project facilities. This selection has not yet been adjudicated, but if approval is required and authorized, direct effects would be minor. There are no other potential operations effects on Borough-owned lands.

Alaska Native Corporation Lands

There are no selected or conveyed Alaska Native Corporation lands in the Project area. For the Project, operations activities will take place on state lands. There will be no effect on ownership of Alaska Native Corporation lands.

Alaska Native Allotment Lands

For the Project, operation activities will take place on state lands. There will be no effect on ownership of Alaska Native allotments

Land and Water Use

Industrial Resource Development Use

Operation of the Project will represent a continuation of oil- and gas-related uses over a larger portion of the Project area, and will result in a moderate decrease in the intensity of use from construction activities direct effects will be minor.

Subsistence and Traditional Uses

Operation of the Project will represent an increase in intensity and area affected compared to those currently permitted at the Central Pad. Subsistence and traditional uses primarily occur in the summer months, associated with caribou hunting and travel through the area. Primary effects on subsistence use include restriction on hunting in the immediate vicinity of construction activities for safety reasons. The presence of industrial facilities may affect the way local residents use the area. Adverse effects are somewhat offset by the advantages of having a facility and personnel in the area in case assistance is needed. The overall effect on subsistence and traditional use is minor to moderate during operations, and should be mitigated by working with hunters from Kaktovik and Nuiqsut. For more information on potential effects about subsistence, see Section 4.3.3.

Recreation and Tourism Uses

Operations activities associated with the Project will represent an increase over currently permitted drilling activities. Operations activities will occur approximately 4 miles closer to the western boundary of the Refuge. Potential operations effects on recreation use are considered minor, but ExxonMobil will work with USFWS to develop measures to mitigate potential Project effects on the Refuge. For more details, see Section 4.3.6, Recreation.

Land Management and Regulations

Federal Management

For the Project, operations activities will take place on state lands. Federal management of the Refuge will not be directly affected. However, indirect visual and noise effects associated with Project operations may have minor conflicts with Refuge management objectives. ExxonMobil will work with USFWS to develop measures to mitigate potential Project effects on the Refuge.

State Management

Operations activities will take place on state lands and will likely require additional management approvals from the State of Alaska. Similarly, as part of the Project, operations must be consistent with the standards of the ACMP. Application for authorizations and consistency reviews will take place concurrent with the NEPA compliance process, and direct effects will be minor.

Borough Management

Permits and approvals for operations will be required to be consistent with the enforceable policies of an approved NSB coastal management plan. In addition, operations are also required to comply with BLM Regulations. Operations activities are expected to comply with BLM requirements with some stipulations, and direct effects will be minor.

TABLE 4-30: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON LAND OWNERSHIP, USE AND MANAGEMENT

Phase	Land Ownership, Use, and Management Concern	Direct Effect	Indirect Effect
Drilling	Land ownership	Minor	None
	Land use	Minor	Minor
	Land management	Minor	Minor
Construction	Land ownership	Minor	None
	Land use	Minor to moderate	Minor
	Land management	Minor	Minor
Operations	Land ownership	Minor	None
	Land use	Minor to moderate	Minor
	Land management	Minor	Minor

4.3.5 Transportation

Drilling, construction, and operations phases of the Project are expected to cause minor effects to the existing transportation systems on the North Slope. Small modules and other materials will most likely be trucked up the Dalton Highway and stored at a central staging area, and subsequently trucked to the Project site over winter ice roads when required. Some equipment and supplies may be barged to Prudhoe Bay, and then transported to the staging area, and subsequently trucked to the site via ice roads. Shipping by barge to the North Slope is only conducted during a short summer season when sea ice recedes along the arctic coast. Smaller landing craft type local barges will likely be used to transport equipment and materials between Prudhoe Bay and Point Thomson as needed during summer months. Air transportation between Prudhoe Bay and Point Thomson is expected to be an important mode of transportation year-round, and will have a minor effect on local airports.

Alaska Clean Seas (ACS) is the entity currently providing the North Slope area with oil spill response, from selected areas of the Alaska Outer Continental Shelf and adjacent shorelines and on the Trans Alaska Pipeline System from Pump Station 1 to Milepost 167 (ACS 2009). An increase in barge traffic would mean ACS would have to have an increased response readiness at Point Thomson. ACS has a full-time staff of 74 employees available for response and is augmented currently by 115 qualified response personnel from companies operating on the North Slope (ACS 2009). ExxonMobil (a participating member) will provide an emergency response boat ramp and store spill response equipment at the Central Pad as part of the Project (ExxonMobil 2009a).

4.3.5.1 Drilling

Effects to the existing transportation systems prior to and during the drilling phase are expected to be minor. Drilling equipment and personnel must be transported to the site and different modes of transportation will be employed to accomplish this.

<u>Marine Transportation</u>

Some drilling equipment and supplies are expected to be transported from Prudhoe Bay to Point Thomson on local barges during summer. Increased barging activities could have a minor effect to West Dock facilities in Prudhoe Bay.

<u>Highway Transportation</u>

The direct effect of drilling operations on the highway transportation systems is expected to be minor. Drilling equipment and supplies will be transported to the Project site by trucks from Prudhoe Bay to the site via ice roads. Increased truck traffic within the BPXA oil field will have a minor affect on local roads.

<u>Aviation</u>

During the drilling phase, personnel, equipment, and supplies will be flown to Point Thomson year-round using helicopters and in some winters using larger aircraft landing on an ice runway. Minor effects on current air transportation systems are anticipated.

Local Skiffs and Snowmachines

The drilling phase of the Project is expected to have a negligible effect on local skiff and snowmachine use. Barging activities during the drilling phase should be light and not impede existing skiff traffic. Ice roads built to transport drilling equipment and supplies to the Point Thomson site may influence where local hunters choose to travel along the coast on snowmachines. Snowmachines can operate on varying terrain and will likely be able to avoid potential hazards caused by ice roads.

4.3.5.2 Construction

During construction, the Project will utilize all forms of transportation now existing in the area. The main consequences during the construction phase would be increased traffic on local roads and dock facilities in Prudhoe Bay.

Marine Transportation

The construction of the Project would have a minor effect to existing local barge routes and surrounding coastal areas. The construction phase will require a significant increase in the number of local barge trips each season to deliver fuel and supplies to the Project site. The local barge traffic increase should not cause significant congestion in barging lanes when combined with the five current local barge trips annually to Kaktovik. The shipping season coincides with the subsistence whaling season; however, local barge activity would be confined to routes inside the barrier islands and subject to a CAA. Delivery of the larger sea-lift modules would be timed to avoid the whaling season.

An increase in the number of barges loading at West Dock would have a moderate direct effect on congestion at West Dock. Local barges can load at Dockhead 1, 2, or 3. The presence of additional local barges, combined with annual sealift barges, may require coordination and queuing of barges waiting to get into the docks to load or unload. The number of barges operating out of West Dock currently is about 50 barges per season and is expected to be increased by an estimated 40 to 80 barge trips per season during construction (ExxonMobil Project Description 2009). This effect on the existing barging system is not expected to require improvements beyond the regular dredging and maintenance currently done to keep docks operational. The sealift modules would not require use of West Dock. The increase in barge traffic would require increased readiness by the emergency response teams in the area.

Highway Transportation

The construction of the Project should have a negligible direct effect on the capacity of the Elliot and Dalton highways. There will be about 1,700 trucks transporting materials up the Elliott and Dalton highways over a period of five years 2009–2014 (Worley Parsons 2009). This averages 340 per year, or less than one truck per day. This would be a 0.3 percent increase in traffic above the current Annual Average Daily Traffic (AADT) of 290 vehicles per day that travel the Dalton Highway. The one-directional capacity of a two-lane gravel road like the Dalton Highway is 1,700 passenger cars per hour (Mannering et al. 2005). The capacity is far greater than the traffic volumes expected during construction.

Modules that will be trucked up the Dalton Highway will be designed to meet the load restriction requirements of the highway. This will minimize the effects to the integrity of the existing highway and minimize the need for additional maintenance to be performed. No improvements to accommodate the proposed truck traffic on the Dalton Highway are expected.

Local roads in the Prudhoe Bay area would also be effected slightly with increased truck traffic due to the transportation of modules, equipment, and supplies from the Dalton Highway and Prudhoe Bay docking facilities to the Project site. Approximately 210 truck trips will occur annually through Prudhoe Bay during construction (Worley Parsons 2009). An ice road will be constructed south of the BPXA road system during the winter months for use between January and April; this will allow truck traffic to bypass the Prudhoe Bay facilities and be trucked directly to the site.

Aviation

Construction of the Project will require up to three flights a day between Deadhorse and Point Thomson at the peak of construction during the 4th quarter of 2012 (ExxonMobil Project Description 2009). Currently there are three daily flights between Deadhorse and Kaktovik, six flights between Deadhorse and Barrow, and three flights to Nuiqsut on weekdays only. The three additional flights per day is an increase of 25 percent above the existing air traffic out of Deadhorse, although the small increase in the number of daily flights would be a minor direct effect to the overall local aviation system. Improvements to the existing system are not expected. Increased air traffic would have a minor indirect effect on recreation flights in the area for sightseeing, as well as hunting and fishing, as more air traffic will need to be coordinated to avoid accidents.

Local Skiffs and Snowmachines

The construction phase of the Project is expected to have a minor effect on local skiff and snowmachine use. Barging traffic during construction should be moderate, but is not expected to impede existing skiff traffic.

Construction of the dolphins for mooring the barges will create a long-term risk of allision (vessel collision with a fixed object). The dolphins will be fitted with reflectors to reduce the risk. The infrequent use of the area by vessels not associated with the Project, the short open water season and the reflectors decrease the likelihood of allision and the overall effect would be minor.

Ice roads associated with the Project and the dolphins protruding from the nearshore ice may influence where local hunters choose to travel along the coast on snowmachines. Snowmachines can operate on varying terrain and should be able to avoid potential hazards caused by ice roads and the dolphins.

4.3.5.3 Operations

After drilling and construction of the Project is complete the volume of equipment and supplies transported to Point Thomson should reduce significantly.

Marine Transportation

Materials and equipment for operations will likely be transported from Prudhoe Bay by local barge only as required (ExxonMobil 2009a). This level of barge activity is expected to have a very minor effect on the overall marine transportation system. The overall minor effect from the risk of allision with the dolphins would continue during operations.

Highway Transportation

During the operation of the Point Thomson field the need for highway transportation is expected to be minimal. Ice roads may be required in subsequent years for future drilling and/or facility improvements (ExxonMobil Project Description 2009). Demobilization of construction equipment would temporarily increase traffic on the highway systems as the construction winds down and equipment is no longer required.

Aviation

Operations of the Point Thomson facility will have a minor affect on air transportation in the area, with flights between Deadhorse and Point Thomson as needed to transport personnel.

Local Skiffs and Snowmachines

Operation of the Project would have a minimal effect on skiff, and snowmachine transportation in the Point Thomson area. Occasional ice road and barge activities are expected to have a negligible effect to skiff, and snowmachine transportation. Mooring dolphins placed at the proposed Point Thomson docking facility are a potential hazard for snowmachines and skiffs traveling along the coast, although the large size of the dolphins should make these potential hazards easy to see and therefore avoid.

4.3.5.4 Conclusion

As shown in Table 4-31, the Project would have overall minor effects to marine, highway, and aviation transportation systems. For the most part, the increase in activity would be within the existing capacity. There could be some congestion at West Dock during construction, although it is anticipated that throughput would be maximized by 24-hour/day operations and quicker loading and unloading using an increased workforce.

TABLE 4-31: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON TRANSPORTATION

Phase	Transportation Concern	Direct Effect	Indirect Effect
Drilling	Marine	Minor	Minor
	Highway	Minor	Minor
	Aviation	Minor	Minor
	Skiffs and Snowmobiles	None	Minor
Construction	Marine	Minor	Moderate
	Highway	None	None
	Aviation	Minor	Minor
	Skiffs and Snowmobiles	Minor	None to Minor
Operations	Marine	None to Minor	Minor
	Highway	None	None
	Aviation	Minor	Minor
	Skiffs and Snowmobiles	None to Minor	None to Minor

4.3.6 Recreation

As described in Section 3.3.6, recreation opportunities on the North Slope include both developed and dispersed recreation activities. In the vicinity of the Project area, activities generally include floating the Canning River, and activities in the Refuge, such as viewing scenery and wildlife, camping, sport fishing, backcountry hiking, and camping. Key factors of the recreation setting include challenging access, outstanding opportunities for solitude and primitive recreation, viewing wildlife, and vast landscapes. The Project could affect recreation activities and settings in the vicinity of the Project area. Table 4-32 at the end of this section summarizes potential direct and indirect effects.

4.3.6.1 Recreation Activities

Recreation activities in the area generally occur during the summer, and therefore would only be affected by summer drilling, construction activities, and regular operations. The Project would provide no direct impediment to recreation activities as currently practiced; however, it could affect the number of recreationists using the area, because of the influx of workers to the area. A small increase in the number of people pursuing recreation activities in the area could substantially increase the percent of use. As discussed in Section 3.3.6, the number of visitors to the Refuge has remained relatively stable over the past 20 years, ranging between approximately 1,200–1,500 per year.

4.3.6.2 Recreation Setting

The Project would alter the recreation setting in the area; setting elements of access, solitude, and landscapes could be moderately affected.

Access

During construction in particular, the Project area will be subject to regular transportation service, including airplanes and boats. Public access to the area is not expected to be affected if access to ice roads is restricted to industrial and local resident use, and air and vessel service is restricted to Project workforce. The change in types and amount of industrial access is expected to create visual and aural effects, potentially altering recreational experience, in particular, opportunities for solitude. Because there are currently scheduled commercial flights between Kaktovik, Deadhorse, Barrow, and Fairbanks, potential effects would consist of an increase in air traffic. There is currently air traffic supporting permitted drilling activities at the Project site, consisting of fixed-wing access when an ice airstrip is operational, and helicopter access during the rest of the year.

Levels of air traffic would be higher for construction activities than for operation. However, construction effects would last for two to three seasons, with the majority of effect occurring during dark and cold winter months. Once a gravel airstrip is constructed, the amount of regular helicopter traffic to the area would decrease over current levels.

Opportunities for Solitude

The industrial activities associated with the Project could generate noise at a level that effects opportunities for solitude in the area, including the Refuge and Canning River corridor. Drilling may create a noticeable increase in noise for a limited time period; however, because of current restrictions, the majority of drilling is planned to take place during winter when recreation activities will be much less likely to occur. 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 miles (18 kilometers) south of the 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; potential effects would be minor to moderate.

Vast Landscapes

The presence of industrial facilities would have visual effects on the recreation setting in the Project area. Communication towers, flares, and lights could potentially be seen from distant viewpoints, as discussed in the analysis of visual aesthetics in Section 4.3.7. Because the majority of recreation takes place in the summer, visual effects from flares and facility lighting are likely to be minimal, given longer Arctic sunlight. Structures such as the high-pressure flare stack (120 feet) and communications tower (200 feet) could be visible from within the Refuge, although their mass is relatively slender. Portions of the main processing facilities could be as high as 85 feet, and would also be visible from high points in the Refuge. Depending on mitigation, potential effects would be minor to moderate.

Mitigation measures are being evaluated to reduce lighting during early fall, and the flares would be placed on the west side of the Central Pad, partially shielding them from view from the Refuge. Options for facility color will be discussed with permitting agencies and other stakeholders during the permit application review and NEPA compliance process.

4.3.6.3 Wilderness Values

The Project would not be located within the Refuge, including the Mollie Beattie Wilderness. The Project would not infringe upon the opportunities for primitive recreation in the area. However, there could be an infringement upon opportunities for solitude, because of increased numbers of flights related to industrial development; sights and sounds of aircraft in the area could increase. In addition, there is concern that there could be aural effects; under the right conditions, there could be sound attenuation in the area from industrial activities, including exploration, construction, or operations. Depending on mitigation, potential effects would be minor to moderate.

TABLE 4-32: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON RECREATION

Recreation Concern	Direct Effect	Indirect Effect
Access	Minor	None to Minor
Opportunities for Solitude	Minor to Moderate	Minor to Moderate
Vast Landscapes	Minor to Moderate	Minor to Moderate
Wilderness Values	Minor to Moderate	Minor to Moderate

4.3.7 Visual Aesthetics

This section describes potential effects to visual and aesthetic resources that may result from the Project. This assessment was summarized from existing data, including the Preliminary Draft Environmental Impact Statement (PDEIS) prepared in 2003. Additional analyses will be required during the preparation of the EIS; key stakeholders should be consulted in the analysis, such as the Refuge, NSB, and residents and governing bodies in Kaktovik. This assessment provided a framework to guide future efforts to describe potential effects to visual and aesthetic resources that may result from the Project.

4.3.7.1 Methodology

Because of the predominantly low-lying growth form of vegetation in the area, bare-ground modeling would be suitable for analysis. Locations within a 30-mile radius of the proposed facility were considered as having the potential for unobstructed views to some portion of the Project (Figure 4-3). This assumption acknowledges the potential viewing distances for an observer on the ground; the viewed horizon is approximately 3 miles from an observer on the ground, a 100 foot tower could be seen from a distance of approximately 12 miles, and a 330 foot tower could be seen from a distance of approximately 22 miles. These estimates assume conditions for visibility, such as daylight and lack of fog.

Visual resources within the study area were evaluated in 2003 using methodology adopted from the Visual Resources Assessment (VRA) procedure for the USACE (Smardon et al. 1988). The analysis typically includes a Visual Impact Assessment (VIA) to identify potential effects to visual resources that may result from the Project.

A detailed VIA had not been completed: a preliminary assessment based on predefined significance criteria has been completed. It is expected that a VIA will be completed at a later date during the NEPA compliance process in consultation with agencies and stakeholders. The VRA included five steps, described as follows:

Classification of Similarity Zones

The study area is classified into Similarity Zones, defined as areas containing similar physical geography and shared characteristics in land formations, water resources, vegetation/ecosystems, land use type, intensity of land use, and proximity to the Project. Proximity to the Project was defined as:

- *Immediate Foreground*: Within 1 mile of the Project,
- *Foreground*: Within 3 miles of the Project,
- *Middleground*: Within 5-15 miles of the Project, or
- *Background*: Greater than 15 miles from the Project.

Management Classification

Similarity Zones are assigned a Management Classification based on existing visual and aesthetic resources. Management Classifications are a reflection of the visual resources present in the area, in addition to the technical, institutional, and public recognition of those resources. Each classification is associated with recommended visual resource objectives that can be applied to the Project. Five visual resource management classes are defined by the USACE VRA procedure (Smardon et al. 1988). Management Classification for identified similarity zones was completed using Form 5 of the USACE VRA procedure. Visual resource management classes are described as follows:

- *Preservation Class:* Assigned to areas that are considered to be unique and to have the most distinct visual quality in the region. They are highly valued and are often protected by federal and state policies and laws. These areas include wilderness areas, some natural areas, portions of Wild and Scenic Rivers, historic sites and districts, and similar situations where changes to existing resources are restricted.
- *Retention*: Assigned to areas that are regionally recognized as having distinct visual quality, but may not be institutionally protected.
- *Partial Retention*: These areas are locally valued for above-average visual quality, but are rarely protected by institutional policies.
- *Modification*: These areas are not noted for their distinct qualities and are often considered to be of average visual quality.
- *Rehabilitation*: These areas are noted for their minimal visual quality and are often considered blighted areas.

Selection of Viewpoints

Viewpoints are chosen to represent typical viewer locations, predominant viewer activity, and Project visibility.

Completion of a Visual Resource Inventory (VRI)

The VRI identifies specific elements of the landscape that determine the landscape quality.

Visual Impact Assessment

The visual quality for each resource component (water, landform, vegetation, land use, and user activity) is assessed and scored for pre- and post-development scenarios. The resulting variation in scores provides an indication of overall scenic quality deviation. Additional modifier ratings describing spatial dominance, scale contrast, and compatibility are assigned to the proposed development. Modifier ratings are described as follows:

- *Spatial Dominance*: The prevalent occupation of a space in a landscape by an object(s) or landscape element;
- *Scale Contrast*: The difference in absolute or relative scale in relation to other distinct objects or areas in the landscape; and
- *Compatibility*: The degree to which landscape elements and characteristics are still unified within their setting.

The following significance criteria were used to develop a preliminary assessment of anticipated effects to visual and aesthetic resources:

- Effect would be considered major where actions would become the dominant feature or focal point of the view, create a modification much larger than surrounding objects, affect sensitive viewers in predominantly foreground and middleground views; and not be considered harmonious with the landscape setting.
- Effect would be considered moderate where actions would become the co-dominant feature or focal point of the view; create a modification appearing slightly larger than surrounding objects; affect sensitive viewers infrequently, or in predominantly middleground and background views; and be considered generally harmonious with the landscape setting.
- Effect would be considered minor where actions would be subordinate in the view, create a modification that is smaller than surrounding objects, affect sensitive viewers in background views, and be considered generally harmonious with the landscape setting.
- No effect would occur if the facilities would be isolated, screened, not noticed in the view, or seen from background distance zones, or no visually sensitive resources would be affected.

4.3.7.2 Visual Resource Assessment

Similarity Zones

Similarity Zones were identified by reviewing topographic maps, aerial photographs of visual conditions in the study area, plan and elevation drawings of the proposed development, and information about land use patterns in the area. Three Similarity Zones were identified within the study area, based largely on changes in water resources and prevailing land use (Figure 4-4). Similarity Zones generally encompassed distinct viewer groups, with little to no overlap. Similarity Zones included the following:

- The Beaufort Sea Similarity Zone is characterized by flat, elliptical islands, oriented in a primarily east-west direction. The Beaufort Sea separates the islands from the mainland during the summer months by approximately 3–5 miles. This Similarity Zone is primarily occupied by local residents engaged in subsistence activities and Arctic tourists.

- The Refuge Similarity Zone is described as the portion of the Refuge within 30 miles of the Project. This area is characterized by the broad, extensively braided channels of the lower Staines and Canning rivers, situated in the backdrop of the Brooks Range to the south. Terrain is flat, and views to the north are dominated by the prevailing horizontal line of the horizon. The Refuge is primarily occupied by the Recreator and Local Resident viewer groups.
- The Oil and Gas Planning Area Similarity Zone includes lands situated west of the Staines River and includes the Point Thomson, Badami, and Slugger areas and surrounding lands within the ACP. This Similarity Zone is primarily occupied by employees at Point Thomson and adjacent oil and gas facilities.

Visual Management Classes

Interim visual management classes (VMCs) for the study area were identified in 2003, using Form 5 of the USACE VRA (USACE 1988). The analysis resulted in the classification of the Beaufort Sea and the Oil and Gas Similarity Zones as Partial Retention, and the Refuge as Preservation. Management recommendations corresponding to each classification are provided in Table 4-33. These classifications will be re-evaluated during the NEPA process.

TABLE 4-33: MANAGEMENT CLASS AND CORRESPONDING MANAGEMENT RECOMMENDATIONS, SIMILARITY ZONES LOCATED IN THE POINT THOMSON PROJECT VISUAL RESOURCES AND AESTHETICS STUDY AREA

Similarity Zones	Management Class	Recommended Management Objectives
Beaufort Sea Oil and Gas Planning Area	Partial Retention	Project activity may be evident and begin to attract attention. Structures, operations, and use activities should remain subordinate to the existing visual resources. Form, line, color, texture, scale, and composition may differ from but should be compatible with the visual characteristics of the existing resource.
The Arctic National Wildlife Refuge	Preservation	Project activity should not appear readily evident. Structures, operations, and use activities should appear to be extensions of the protected resource and should faithfully represent, repeat, or reinforce the visual character of that resource.

Key Viewpoints and Visual Resource Inventory

Four key viewpoints representing viewer positions in the Refuge and the nearshore Beaufort Sea Similarity Zones were selected to assess effects to visual resources from the proposed facility (Figure 4-5). Because viewer sensitivity among employees of the Point Thomson and Badami facilities were considered to be low, a detailed assessment of effects to visual resources is not warranted for lands located in the Oil and Gas Planning Area similarity zone.

Existing conditions were assessed using photographs provided by the USFWS. However, a detailed VRI should be conducted during the NEPA process, in consultation with agencies and stakeholders. Landscape characteristics should be described, such as form, line, color, and texture.

Key viewpoints within the 30-mile radius included:

Beaufort Sea (1 Mile Offshore)

This viewpoint is contained in the Beaufort Sea Similarity Zone. Views toward the mainland from this viewpoint are dominated by the strong horizontal lines created by the vast, flat terrain of the ACP and the vertical and diagonal lines of the Sadlerochit Mountains. Summer coloration of the ACP is greenish-brown, with noticeable white, snow-capped peaks visible in the background. Water is deep blue to grey. Winter months are characterized by contiguous white snow and ice cover that extends from the barrier islands, across the ACP to the foothills and Brooks Range to the south. Existing structures includes two drill units located on the Central Pad. The drill units create vertical lines that contrast with existing horizontal lines of the ACP and shoreline; however, the lines are largely absorbed by the surrounding landscape. Faint views of the Badami Unit to the west are also visible. The Central Pad is visible from the water; however, the extent of the pad that can be viewed depends on the vantage point of the viewer. The Central Pad contains a variety of drilling equipment; however, all are stored in a way that minimizes vertical contrast. The primary visual receptor located in the nearshore Beaufort Sea includes local residents engaged in subsistence activities. This population is classified as having high viewer sensitivity. Secondary viewers include Arctic tourists, whose sensitivity is classified as moderate.

USFWS Temporary Camp

The USFWS temporary camp is located approximately 6 miles away from the east well pad, within the Refuge Similarity Zone. Views from the temporary camp include the expansive ACP and the backdrop of the Sadlerochit and Shublik mountains to the south. Although this location is not considered a significant public use area (Wheeler 2003), it is does represent views of the proposed development from relatively close proximity.

The Canning River Take-out

This viewpoint is also located in the Refuge Similarity Zone, approximately 20 miles south of the proposed facility. The terrain is flat, and views include the braided river channels with a distant view of the Brooks Range to the south. This location represents a Recreator viewer position located within the background distance zone.

The Oil and Gas Planning Area

The Oil and Gas Planning Area Viewpoint is located in the Oil and Gas Planning Area Similarity Zone. Views of this area are dominated by the remote and expansive coastal plain, with few, isolated structures or developments. The geographic area surrounding Point Thomson is characterized by flat terrain and low-lying vegetation. Numerous oval- to elliptical-shaped ponds are present. During summer months, the predominant landscape color is green and blue/grey; however, the majority of the year, white snow and ice dominate this landscape.

Considerations for Additional Analysis

The Sadlerochit Mountains are located just beyond the calculated radius, in the Refuge Similarity Zone. Due to the sensitivity of viewers in this area, viewpoints such as this, in areas of higher elevation, should be considered for evaluation in the detailed VRI.

4.3.7.3 Effects Analysis

The magnitude, extent, and nature of potential effects to visual resources will depend on the viewer's position relative to the proposed facility, the duration of time spent in that location, the angle of the view, and the sensitivity of the viewer. For the purposes of this assessment, a description of potential effects is included below, followed by a site-specific evaluation of potential effects to visual resources.

Potential Effects

Drilling

Drilling operations have the potential to result in direct effects on visual resources and aesthetics because of the visual contrast created by drilling structures. Additional effects may result from the construction of ice roads that may introduce new linear features to the landscape and may be visible in both winter and summer months. Increased air and water traffic may also create effects on visual resources by interrupting the natural landscape.

Construction

Construction of the Applicant's Proposed Development (Alternative 2) has the potential to result in direct effects on visual and aesthetic resources because of the following actions:

- Construction of ice roads, gravel roads, airstrip, and pads;
- Construction of bridges;
- Construction of facilities;
- Construction of export and in-field pipelines;
- Gravel mining;
- Construction of mooring dolphins and temporary grounding of barges for a barge bridge dock;
- Construction of temporary work camps; and
- Increased air and marine traffic/activity.

Views of construction equipment may create strong visual contrast against the backdrop of the natural environment and would be most evident to viewers located within 1 mile of the proposed facility during periods of natural light. Construction activities may also be visible at greater distances if lighting is used to aid in night-time construction. Increased air and water traffic associated with construction may also create effects on visual resources by interrupting the natural landscape.

Construction of sea- and land-based ice roads and bridges may result in the addition of linear features to the landscapes that have high contrast against the exiting ground plane. Lines may result from disturbance to the ground plain (tundra compaction) and also because of delayed snow melt resulting from increased albedo. Gravel mining operations may interrupt views by scarring ground plain and creating a visually contrasting mining footprint.

Views of construction-related dust may affect viewers located within 5 miles of the proposed facility; however, construction-related dust is unlikely to result in increased atmospheric haze that would be evident at the regional scale region (see Section 3.1.1, Meteorology and Air Quality). There will be regular aircraft (primarily helicopter and barge traffic during the summer months and fixed-wing aircraft and vehicle traffic during the winter month).

Up to 400 people are expected to be involved in construction of the facility during the first quarter of 2013. The amount of people working on construction activities will increase activity levels in the Project area and could affect visual quality.

Operations

Operation of the Project has the potential to directly affect visual and aesthetic resources because of the following elements:

- Structures (CPF, flare stacks, pipelines, and wells);
- Light and glare;
- Maintenance;
- Gas turbines and heater exhaust stacks (periodic plumes of water vapor may be visible); and
- Increase in land-based and marine activity.

Primary visual effects from structures may result from the strong contrast between structures and the undeveloped backdrop of the ACP. Such effects would be most evident during the day and from vantage points located within 3 miles of the facility (Figure 4-5). Effects from light and glare may result from the use of lighting on facilities and the airstrip, and occasional flare from the CPF. The flare would be ignited periodically in order to depressurize facilities or pipeline. Effects of light and glare will be most evident during periods of darkness and may be visible from greater distances. Periodic plumes of water vapor may be visible from gas turbines and heater exhaust stacks. As with the flares, emission of water vapor will be episodic.

The proposed facility would employ approximately 75 persons during operations, with more than 100 present during planned and emergency maintenance operations. The increased number of people would contribute to heightened activity in an otherwise quiet and serene environment. Depending on the number of people located on site, or the amount of marine and air traffic to and from the site, increased activity could affect visual quality in the area.

Site-specific Effects Analysis

Preliminary assessments of effects to visual quality during daylight and non-daylight conditions were completed in 2003 for viewpoints, including the Beaufort Sea (1 mile offshore), USFWS Temporary Camp, and the Canning River Take-out. A viewpoint assessment is not warranted for the Oil and Gas Planning Area Similarity Zone, as viewers in that location (i.e., facility employees) are not considered sensitive viewers. It is expected that additional simulations will be produced during the NEPA compliance process to support a more detailed analysis of potential visual effects and determination of compatibility with VMCs.

Beaufort Sea (1 Mile Offshore)

On the basis of the results of the 2003 VIA, direct effects to visual and aesthetic resources from drilling, construction, and operation of the Project, as viewed from the Beaufort Sea nearshore environment, are expected to be moderate. Drilling equipment and associated ice roads may be visible from the Beaufort Sea; however, equipment is expected to be of small-enough stature that it may not dominate views. Drilling equipment is not expected to require lighting, thereby reducing the potential to affect night-time views. Construction activities are expected to be discernable from this viewpoint; however, potential effects are expected to attenuate with distance from construction activities. Increased construction-related travel to and from the study area is expected to be coordinated to minimize overlap with sensitive receptors (i.e., Local Residents). Views of the mainland from the Beaufort Sea are expected to be effected because of the level of contrast created by the existing structure. However, because of the vast, open landscape of the ACP, the structure is not expected to dominate the landscape.

USFWS Temporary Camp

The USFWS Temporary Camp represents a point from which recreators could view the proposed facility. Direct effects to visual or aesthetic resources resulting from drilling, construction, and operation may be discernable at this location; however, the facility is not expected to dominate the landscape or substantially change the existing visual quality of this location. The greatest effect to visual quality is expected to occur during non-daylight hours, when the effects of facility lighting would be evident in the night sky. Potential effects of lighting may be minimized if the majority of use occurs during periods of prolonged daylight during summer months.

On the basis of the preliminary assessment, direct effects to visual and aesthetic resources resulting from operation of the Project as viewed from the USFWS Temporary Camp are expected to be moderate. Because of the distance of this viewpoint, construction-related effects to visual quality are expected to be minor. Effects to visual and aesthetic resources resulting from drilling operations are expected to be minor. Drilling equipment is not expected to dominate views from this location. Ice roads are not expected to be visible, because of the flat topography of the surrounding area. Increased air and water travel is expected to only occasionally overlap with visitation to this camp.

The Canning River Take-Out and the Sadlerochit Mountains

Simulations produced in 2003 for the Canning River Take-out viewpoint indicated that the facility would be barely perceptible from this location. On the basis of a preliminary assessment, direct effects to visual and aesthetic resources, as viewed from the Canning River Take-out, are expected to be minor. Potential effects may be minimized because light attenuation from the facility would not affect recreationists in the prolonged daylight during the summer months when river recreation occurs. Because of the distance of this viewpoint from the proposed facility, construction activities are expected to have no effect on visual quality. Potential effects resulting from drilling are expected to be minor. Drilling equipment is not expected to dominate views from this location. Because no lighting is used for drill rigs, effects to night-time views are not anticipated.

4.3.8 Environmental Justice

As described in Section 3.3.8, the evaluation of potential consequences related to environmental justice focuses on the NSB and the two NSB communities of Kaktovik and Nuiqsut. This section addresses potential environmental justice effects of the Project on these communities and their ties to the North Slope region. Concerns regarding employment, subsistence, cultural aspects of Iñupiat culture, health, and safety will be evaluated during the NEPA Process for the Project, and in the assessment of potential health impacts to be completed by the USACE and State of Alaska.

4.3.8.1 Direct and Indirect Effects of Drilling

During the drilling phase of the Project, local and regional workers will be employed in a variety of jobs, services and contracts, including personnel, logistical and food services contracts. Local residents may seek temporary or permanent employment with ExxonMobil or through opportunities with Alaska Native corporation subsidiaries and other companies. Some resident workers will seek to balance a work routine with maintaining subsistence activities; the potential direct effect of this employment venture may result in some personal conflict in choosing to provide a cash supplement to their income and diminished opportunities for participation in a subsistence lifestyle (it should be noted that much of the drilling activity occurs during the winter, which is after key harvest and gathering periods). This effect may be minor to moderate, depending on the number of local residents employed during the drilling phase and would be offset to some degree by income from employment and contribution to support of community subsistence activities. There is evidence to suggest that active participation in the wage economy is associated with greater activity in subsistence activities.

During the drilling phase, the Project will schedule barge activities to reduce the potential effect on whaling and improve safety through a CAA. An indirect effect of drilling is that the Emergency Response Boat Launch hosts additional safety vessels that could be launched in case of an emergency or to respond to a search and rescue request. The Project area's location lends itself to having additional resources available for response to an emergency. This potentially improves the safety, health, and well-being of local travelers and/or subsistence harvesters.

As described in Section 4.2.6, the potential effect of the drilling phase on caribou herds (CAH and PH) is minor. There is a short duration (temporary) of interaction, and the majority of the work will take place in the winter, when the likelihood of interaction with caribou is low. For hunters or trappers, arctic fox is the mammal which may be affected the most, but conclusions in Table 4-22 indicate that the effect is minor. There is little to no potential interaction of the drilling phase on the local residents' access to traditional use sites, camps, and cemeteries. There are no anticipated effects on human health or contaminant exposure effects for Kaktovik and Nuiqsut residents associated with the drilling phase of the Project.

4.3.8.2 Direct and Indirect Effects of Construction

The two to three year construction phase will feature the periods of most concentrated activity in the Project area. As summarized in Chapter 1 and described in more detail in the Project Description, this phase consists of construction of roads, pipelines, camps, and the bulkheads. During the construction phase of the Project, local and regional workers will be employed by in a variety of jobs, services and contracts, including personnel, and logistical and food services contracts. As addressed in Section 4.3.8.1, local residents may seek temporary or permanent employment. The potential effect may be minor to moderate, depending on the number of local resident employed during the drilling phase. Also, as addressed previously, it is likely that some newly-employed workers may have a personal conflict in supplementing their income and in reckoning a diminished opportunity to pursue subsistence activities. The resulting indirect effects of this employment could be an increase in public and health services required by local residents.

The potential interaction for construction-related barge traffic would be mitigated through the CAA (e.g., reducing or suspending barge activity during whaling); and therefore, the direct effect would be none to minor. In addition to an increase in marine traffic during the construction phase, air traffic would be more frequent, which has the potential to disturb wildlife and potentially decrease subsistence hunting success and otherwise affect other traditional activities. Mitigation to decrease this potential effect would include directing pilots to fly specific routes at altitudes that minimize disturbance to terrestrial and marine mammals. Similar to the drilling phase, the indirect beneficial effect having a facility between Kaktovik and Prudhoe Bay and more vessels increases emergency response capabilities.

According to the analysis in Section 4.2.6, portions of the CAH and PH may be most affected by the noise and traffic around the Project area. This minor to moderate effect may result in a minor to moderate effect on subsistence hunting. As shown in Figures 3-33, 3-34, 3-42, and 3-43, historical subsistence use areas for both Kaktovik and Nuiqsit abut the Project area. Recent use of these abutting areas by Nuiqsut residents has been negligible, while use of the Brownlow Point/Canning River delta by Kaktovik residents is regular and in some years quite significant in terms of the overall community caribou harvest. Portions of the CAH and PH could be affected by the construction operations, and the hunters themselves may be affected by the increased activity on and near the Project area. As noted in Section 4.3.3, "Effects on subsistence and traditional land use can be caused by direct or indirect actions of the Project that result in decreased subsistence use opportunities or a displacement or reduction in subsistence animals." This displacement could result in fewer successful caribou hunts, which may affect the lifestyle and diets of local residents. Residents could have concerns about potential contamination of harvested caribou. The construction phase has a plan focused on mitigation measures to reduce the potential effect of spills or contaminants being released into the local environment. While there is a potential for a release, it is not likely during the construction phase. If a release does occur, its direct and indirect effects would be minor to major, depending on the size of the release and into which medium (e.g., air, water, soil).

Continued frequent communication with local residents and implementation of Project field policies that are developed with community input will mitigate potential conflicts over access to traditional use sites, camps, and cemeteries. There is the possibility of a “displacement effect” of subsistence hunters from areas abutting the Project area if, even with adequate access mitigation measures, Project activities still degrade the hunting experience or otherwise affect the local hunters’ sense of place for these hunting areas. It can be expected that mitigation measures will result in little direct or indirect effects on access. Displacement of subsistence hunters from use areas abutting the Project area will range from negligible to moderate, depending on the success of mitigation measures. Since the construction phases of the Project will be confined primarily to the winter, these effects would be expected to be closer to the minimal end of that range.

4.3.8.3 Direct and Indirect Effects of Operations

The longest Project phase is operations, which will have both short-term and long-term effects on employment and the local tax base. The length of this phase results in more permanent positions that may employ local residents. As noted in 4.3.8.1, these workers may experience some conflicts with subsistence scheduling by working full-time at the Project. This effect may be minor to moderate, depending on the number of local resident employed during the operations phase.

In addition to the potential local jobs created by the Project (referenced in 4.3.8.1 and 4.3.8.2), the tax base for the Project’s operations may provide a moderate positive benefit to the local communities. This tax base might result in an improvement and increase in health and public services and facilities; thereby, improving upon the quality of life for local residents. In reviewing the NSB Comprehensive Plan (NSB 2005), types of public projects that are valued by communities and foster preservation of the Iñupiat way of life would be facilities such as community and youth centers, cultural centers, and educational initiatives.

As noted in Section 4.3.8.2, the CAA would ensure the communication and scheduling of marine traffic does not affect subsistence whaling. The direct effect would be little to none, and there is no indirect effect.

Although Table 4-22 indicates that the interaction between the operations phase and mammals is low, it is long-term. This duration increases the potential effect of the operations phase on subsistence, resulting in a minor to moderate effect. Hunters tend to utilize areas closer to their communities, but the potential displacement of portions of the CAH and PH away from the Project area (due to noise or other operations) should need to be monitored. As stated in Section 4.3.3.3, “it will be necessary to regularly consult with Kaktovik hunters about such potential disturbances to hunters and/or wildlife such as operation noises, traffic and dust on roads and gravel pads, the flaring of gas, aircraft noise and visual over flights, and barge traffic.” Caribou and/or hunters may be deflected from traditional subsistence lands by the noise emitting from the Project site or the placement of the pipeline. This consultation mitigation measure may decrease the potential effect from moderate to minor and will promote safety awareness as hunters access the Project area for transit to and from traditional lands and among neighboring communities.

As discussed above, local residents are concerned about the potential contamination of the food chain due to a spill or pollutant emission. Section 4.4 describes the spill risk, and Chapter 5 lists the mitigation measures to prevent a potential spill and outline the rapid response to contain a pollutant discharge and reduce the potential effect to the environment.

Lastly, communication with local residents will help mitigate potential conflicts when accessing traditional use sites, camps, and cemeteries. This mitigation should result in little to no direct or indirect effects on access.

4.3.8.4 Conclusions

Ensuring NSB communities are consulted about land access, job training, and scheduling, traditional knowledge and respect for community values will be help produce local project benefits without negative cultural effects. These mitigation efforts will reduce the potential effects of the Project's three phases on local residents and the resources on which they rely (e.g., bowhead whales and caribou). Table 4-34 summarizes the potential direct and indirect effects on the North Slope Borough communities' concerns.

TABLE 4-34: SUMMARY OF DIRECT AND INDIRECT EFFECTS ON ENVIRONMENTAL JUSTICE

Phase	Environmental Justice Concern	Direct Effect	Indirect Effect
Drilling	Employment	Minor	Minor (positive)
	Whaling	Minor	Minor
	Hunting	None	None
	Safety	Minor (positive)	Minor (positive)
	Access	None	None
Construction	Employment	Minor to Moderate	Minor (positive)
	Whaling	None to Minor	Minor (positive)
	Hunting	Minor to Moderate	Moderate
	Safety	Unquantifiable	Minor (positive)
	Access	None	None
Operations	Employment	Moderate (positive)	Moderate (positive)
	Revenue	Moderate (positive)	Moderate (positive)
	Whaling	None	None
	Hunting	Minor to Moderate	Minor to Moderate
	Safety	Minor (positive)	Minor (positive)
	Health	Minor (positive)	Minor (positive)
	Access	None	None

4.4 PRODUCT SPILL RISK ANALYSIS

This section assesses product spills and the relative effects that could result from the release of these products during development and operations at the Project site. "Product" encompasses petroleum hydrocarbons such as crude oil, gas condensate, and refined petroleum products, as well as hazardous substances. Spills, leaks, or blowouts at the Project facility could consist of mostly gas and crude oil at the wellheads and gathering lines, and liquid condensate and crude oil from the export line connecting to the Badami Development. Hazardous substances, such as corrosion inhibitor and other chemicals typically present at exploration and production facilities, not classified as a petroleum product, may also be potentially spilled. In addition, produced water which will be removed from the product stream at the Central Pad 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 spill. Lack of substantial experimental data regarding spill behavior of the Point Thomson condensate product under the extreme conditions expected, and its effects on the environment, contribute to this uncertainty.

Assumptions must be made to analyze the effects of potential 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 have been informed by project-specific engineering calculations, modeling results, and statistical analyses that account for reservoir characteristics such as pressure. This section discusses the probability of an oil spill occurring, on the basis of historical oil spill records and prevention- and response-planning strategies. After analyzing the potential of an oil spill occurring, the effects of an oil spill are considered.

ExxonMobil is committed to the prevention of spills from operations. In 2008, the number of spills greater than one barrel was down internationally by more than 60 percent since 2001. The operation-wide total volume of hydrocarbons spilled in 2008 was about 20,000 barrels, most of which was recovered at the site of the spill. ExxonMobil's spill performance is a result of effective operations integrity management, ongoing upgrades, key equipment replacements, and comprehensive inspection and surveillance programs (ExxonMobil 2008).

ExxonMobil is committed to operating responsibly by implementing scientifically sound, practical solutions to meet energy needs in an environmentally responsible manner. This commitment has been communicated in detail across all business lines and at all levels. It is the long-standing policy of ExxonMobil to consider both the environmental and economic needs of communities where business is conducted. ExxonMobil seeks to minimize incidents with environmental impact to zero, and to operate in a manner that is not harmful to the environment. ExxonMobil senior management have reinforced expectations to all business lines for superior environmental performance. This leadership-driven initiative is called **Protect Tomorrow. Today.**

The Project will use ExxonMobil's Operations Integrity Management System (OIMS) to drive continuous improvement in environmental performance. This system uses direct input from technical specialists and field operations personnel, along with information developed through routine hazard loss and incident investigations, to minimize the potential for recurrence of incidents. ExxonMobil developed OIMS to better manage safety, health, and environmental risk. Comprehensive risk assessments will be used to identify risks and mitigate the consequences of incidents by providing essential information for decision-making. The implementation of appropriate safety and occupational health programs are also covered by OIMS. The 11 elements of OIMS include:

1. **Management, Leadership, Commitment, and Accountability.** Employees are held accountable for safety, security, health and environmental performance.
2. **Risk Assessment and Management.** Systematic reviews evaluate risks to help prevent incidents.
3. **Facilities Design and Construction.** All construction projects, from small improvements to major expansions, are evaluated early in their design for safety, security, health and environmental impact.
4. **Information and Documentation.** Information that is accurate, complete and accessible is essential to safe and reliable operations.
5. **Personnel and Training.** Meeting high standards of performance requires that employees are well-trained.
6. **Operations and Maintenance.** Operations and maintenance procedures are frequently assessed and modified to improve safety and environmental performance.
7. **Management of Change.** Changes must be evaluated for safety, security, health and environmental impact.
8. **Third-Party Services.** Safe, secure and environmentally responsible operations are required.
9. **Incident Investigation and Analysis.** Incidents and near misses" are investigated.
10. **Community Awareness and Emergency Preparedness.** Thoughtful planning leads to appropriate community involvement. Careful preparation can significantly reduce the impact of an incident.
11. **Operations Integrity Assessment and Improvement.** A process that measures performance relative to expectations is essential to improved operations integrity.

Procedures exist for actual incidents and near misses to provide for a timely investigation that includes root cause analysis to identify contributing factors and determine actions needed to reduce the risk of the incident or near miss. Findings are retained and periodically analyzed to determine where improvements to practices, standards, procedures or management systems are warranted, and used as a basis for improvement.

At the Project site, ExxonMobil requires its employees and contractors to report all spills of oil, regardless of size, to the Lead On-site ExxonMobil Supervisor. ExxonMobil may also elect to streamline spill reporting and have certain spills reported directly to the appropriate agencies by designated field personnel. The Lead On-site ExxonMobil Supervisor is responsible for ensuring that the appropriate supervisor or manager in Anchorage is promptly notified of spills.

The Lead On-site ExxonMobil Supervisor or Manager based in Anchorage initiates further reporting. The Anchorage supervisor or manager provides preliminary information about the size and movement of the spill, including whether the discharge is continuous and the estimated time of arrival to sensitive areas, if applicable.

In the event of a spill requiring notification of the Federal On-Scene Commander (FOSC), the Qualified Individual (the ExxonMobil representative available 24 hours a day) will be notified and will ensure that agency notification occurs. ADEC regulations require notification to ADEC of certain spills on state lands or waterways. After notification of the discharge has been made to ADEC, ADEC will, at its discretion, require interim reports until cleanup has been completed. A written final report must be submitted within 15 days of the end of cleanup operations, or if no cleanup occurs, within 15 days of the discharge. Additional reporting requirements include the following federal, state, and local agencies:

- **National Response Center**: The National Response Center will be contacted to initiate the reporting process for any spill that requires federal reporting.
- **Environmental Protection Agency:** Any spill to navigable waters of the United States or to land that may threaten navigable waters; tundra is considered navigable water;
- **U.S. Coast Guard:** Any spill to or threatening navigable waters;
- **U.S. Department of the Interior, U.S. Fish and Wildlife Service:** Any spill that poses a threat to fish and wildlife;
- **U.S. Department of the Interior, Minerals Management Service:** All spills to marine waters;
- **Alaska Department of Natural Resources:** Same agency reporting requirements as the ADEC;
- **Alaska Oil and Gas Conservation Commission:** All spills from wells or involving any loss of crude oil; and
- **North Slope Borough:** Any spill to water; and spills to land or secondary containment that are greater than 55 gallons.

The Regulatory Compliance Group (RCG) notifies ExxonMobil management and makes the required notifications to ExxonMobil business groups for a Tier II or -III response in accordance with internal procedures. Depending on the type and amount of material spilled, individual government agencies have varying oral and written reporting requirements that ExxonMobil meets. These reporting events are carefully tracked using an internal compliance database.

The Project Drilling Program has developed a comprehensive spill prevention program that has been integrated into each project phase. Potential spills at the Project facility would most likely be related to everyday operations, such as fuel transfers and vehicles. Studies have shown that large spills, such as uncontrolled blowouts, are rare at the exploration and production stages, because spill sizes are limited by production rates (BLM 2004). Large spills are less likely to occur and are limited by the amount of product typically stored at the exploration or production facility (BLM 2004).

The risks associated with potential spills and the potential relative effects on the Project's resources are analyzed in this section. Spill risk analysis addresses the probability of an oil spill, the behavior of spilled oil, and the environmental fate or behavior of spilled oil once it has been released into the environment. Product spill effects are reviewed with respect to effects to physical/chemical resources and biological resources. The spill effects analysis has been separated into the three different phases of the Project development: drilling, construction, and operations.

An ODPCP, demonstrating effective oil discharge prevention, control, containment, clean-up, and disposal of any size spill, including the greatest possible discharge that could occur, is required by Title 18, Alaska Administrative Code, Part 75.425 (18 AAC 75.425) (subject to Alaska Statute 46.04.030). In accordance with ADEC requirements, the Project ODPCP addresses specific conditions that might reasonably be expected to increase the risk of discharge, and actions taken to eliminate or minimize them. Oil spill containment and control actions are required by Alaska Statute 46.04.020; hazardous substance clean-up is required by Alaska Statute 46.09.020. Additional regulatory actions and requirements that have the potential to prevent or mitigate oil spills are provided in Table 4-35.

TABLE 4-35: KEY PREVENTION AND MITIGATION REGULATORY REQUIREMENTS

Regulatory Agency	Permit / Approval Actions / Requirements
Federal	
U.S. Environmental Protection Agency (EPA)	**Spill Prevention Control and Countermeasures (SPCC) 40 CFR 112** regulates all oil bearing containers in excess of 55 gallons. **Facility Response Plan (FRP)** Per 40 CFR 112 Subpart D, ExxonMobil Production Company operations located at Point Thomson, Alaska, require the development of an FRP.
Occupation Safety and Health Administration (OSHA)	**Hazardous Waste; Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) 29 CFR 1910.120** OSHA's role is to assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the states in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health.
U.S. Department of Transportation (USDOT): Pipeline Hazardous Materials Safety Act (PHMSA)	Analyzing pipeline safety and accident data Evaluating which safety standards need improvement and where new rulemakings are needed Setting and enforcing regulations and standards for the design, construction, operation, maintenance, or abandonment of pipelines by pipeline companies Educating operators, states and communities about how to keep pipelines safe Facilitating research and development into better pipeline technologies Training state and federal pipeline inspectors Administering grants to states and localities for pipeline inspections, damage prevention, and emergency response www.phmsa.dot.gov

Regulatory Agency	Permit / Approval Actions / Requirements
U.S. Coast Guard (USCG)	**Facility Operations Manual (FOM) 33 CFR 154.300** provides the requirement for the FOM. The FOM describes how the applicant (ExxonMobil) meets the operating rules and equipment requirements prescribed by this part and Part 156 of this chapter; describes the responsibilities of personnel under this part and Part 156 of this chapter in conducting transfer operations; and includes translations into a language or languages understood by all designated persons in charge of transfer operations employed by the facility. For the Point Thomson facility, the standard language for the FOM will be English. **Facility Response Plan 33 CFR 154.1010** As facility operator, ExxonMobil Production Company developed an FRP to fulfill the regulatory requirements of 33 CFR 154.1010.
State	
State Pipeline Coordinators Office (SPCO) (office within JPO)	Responsible for the administration and oversight of pipeline right-of-way (ROW) leases issued under Alaska Statute (AS) 38.35 Processing ROW applications Drafting leases for Commissioner approval and monitoring compliance with lease conditions. Implementing the public review process Issuance of project specific authorizations www.jpo.doi.gov/SPCO/SPCO.htm
Alaska Department of Environmental Conservation (ADEC)	Approves financial responsibility for cleanup of oil spills (18 AAC 75). Reviews and approves the Oil Discharge Prevention and Contingency Plan and the Certificate of Financial Responsibility for storage or transport of oil under AS 46.04.030 and 18 AAC 75. The State review applies to oil exploration and production facilities, crude oil pipelines, oil terminals, tank vessels and barges, and certain non-tank vessels. Issues a Title V Operating Permit and a Prevention of Significant Deterioration (PSD) permit under Clean Air Act Amendments (Title V) for air pollutant emissions from construction and operation activities (18 AAC Chapter 50). Reviews and approves solid waste processing and temporary storage facilities plan for handling and temporary storage of solid waste on federal and state lands under AS 46.03.005, 010, and 020; and 18 AAC 60.430.
Alaska Department of Public Safety	**State Fire Marshall 13 AAC 50.025** enforces the Alaska State Fire Code; the International Fire Code (2006) includes oil spill prevention requirements (Sections 2206 and 3404).
Alaska Oil and Gas Conservation Commission (AOGCC)	AOGCC's goal for oversight of drilling activities is to ensure the prevention of waste of hydrocarbon resources as well as provide adequate protection for freshwater aquifers. Issues permits to drill, according to the statutory authority, AS 31.05.090. AS 31.05.030(j) addresses permits to drill nonconventional gas. Pertinent regulations to drilling include 20 AAC 25.005 through 25.080, and permits to drill are particularly addressed in 20 AAC 25.005. Surveillance activities and inspection programs including: meter proving, mechanical integrity testing, blowout preventer testing, plugging and abandonment, location clearances, and safety valve testing. www.state.ak.us/admin/ogc/functions/OvrSurvIndex.html#PTD

Notes:
AAC = Alaska Administrative Code
AOGCC = Alaska Oil and Gas Conservation Commission
AS = Alaska Statute
CFR = Code of Federal Regulations
FOM = Facilities Operation Manual
FRP = Facility Response Plan
ROW = right-of-way

4.4.1 Probability of an Oil Spill

This section examines the probability of an oil spill as a result of the Project. For the purposes of this evaluation spills are defined as:

- Very small: less than 10 gallons;
- Small: 10 gallons to 99 gallons;
- Large: 100 gallons to 1,000 gallons; or
- Very large: greater than 1,000 gallons.

This size classification is similar to the spill categorization used by the ADEC for the evaluation of spill data (BLM 2004). This product spill risk analysis focuses on the probability and potential impacts of hydrocarbon spills.

The potential sources of spilled material include vehicles, maintenance equipment, operational equipment, storage tanks and containers, construction equipment, operational equipment, injection facilities and produced-fluid pumping facilities, and storage tanks and containers at the drilling and production pads. These potential sources also include gathering lines for produced fluids, diesel, and water. Blowouts at the Project facility could result in gas and crude oil releases at the wellheads. Gathering lines could release gas and hydrocarbon liquids. Condensate could be discharged from the export pipeline connecting to the Badami Development. Operational spills could also potentially occur.

Human errors often are a significant factor in spills, particularly small and very small spills. Human error can be a “root cause” of a spill, such as a poorly designed or constructed valve which fails after a period of time. Inattention is a frequent human error that results in oil discharges. Rigorous and frequent training of personnel working at the facility is an effective mitigation tool for human errors.

4.4.1.1 Probability of Very Small and Small Spills

The oil and gas industry has been actively exploring and producing North Slope resources for more than 30 years. In this time, the vast majority of oil, produced fluid, seawater, and other industry-related spills have been less than 10 gallons (0.238 bbl) (ADNR 2009). The most common small spills are reported as resulting from diesel, hydraulic fluid, transmission oil, and antifreeze on gravel pads, roads, and airstrips, or onto ice pads. These spilled materials are commonly confined to the built environment, such as roads, ice roads, production pads, or airstrips. Given the small volume, these spilled materials do not typically reach tundra or bodies of water.

Relatively small spills are frequent at North Slope facilities, and the probability of a spill less than 100 gallons is high. From an environmental standpoint, small spills are generally less significant than large spills, because they are typically contained and cleaned up at the site of the spill and, therefore, they are less likely to cause significant adverse environmental effects (NRC 2003). A review of the crude oil and product spills from 1977 to 1999 shows that 50 percent of North Slope crude spills were less than or equal to 0.238 barrel (10 gallons), and 50 percent of the product spills were less than or equal to 0.119 barrel (5 gallons) (NRC 2003).

Small spills at the Project are likely to occur during all phases of the Project development. See Table 4-36 for an overview of potential Project spills and their probability.

TABLE 4-36: ANALYSES OF POTENTIAL DISCHARGES AND SPILL PROBABILITY BY PHASE

Potential Source	Potential Cause	Potential Product	Potential Size	Project Phase and Spill Probability
Equipment/vehicle leaks	Hose ruptures, gasket leaks, etc.	Hydraulic	Very Small <10 gallons (<0.25 barrel [bbl])	Drilling - High Construction - High Operations - Low
Diesel transfer from barge to diesel tank	Hose rupture	Diesel	Large 440-880 gallons (18,480 to 36,960 bbls)	Drilling - Low Construction – Low Operations - Low
Diesel tank	Tank rupture	Diesel	Very Large: 205,000 gallons (4,900 bbls)	Drilling – very low Construction – very low Operations – very low
Oil well blowout	Uncontrolled flow from wellbore	Brookian crude	Very Large: up to 3.57 million gallons (85,000 bbls)	Drilling – Very Low Construction – Very Low Operations – Very Low
Gas condensate well blowout	Uncontrolled flow from wellbore	Thomson Sand gas condensate	Very Large 59,472 gallons (1,416 bbls)	Drilling – Very Low Construction – Very Low Operations – Very Low
Gas condensate pipeline spill	Rupture of product pipeline	Thomson Sand gas condensate	Very Large: >420,000 gallons (10,000 bbls)	Drilling – NA Construction – NA Operations – Very Low

Notes:
bbl = barrel
bbls = barrels
NA = not available
< = less than

4.4.1.2 Probability of Large Spills

Large spills in the range of 100–1,000 gallons are less common; however, they do occur. According to the Alpine Satellite Development Plan Final EIS (BLM 2004):

> *"In the Northeast National Petroleum Reserve-Alaska IAP/EIS (BLM and MMS 1998b) and based on data for spills on the North Slope from January 1989–December 1996, the BLM estimated the average crude oil spill at approximately 160 gallons and the median size at approximately 7 gallons. For this data approximately 99 percent of the spills were less than 1,050 gallons."*

On the basis of BLM analysis of North Slope spills from January 1995–August 2003 the rate of occurrence on average for hydrocarbon spills between 100–1,000 gallons is low; however, the rate of occurrence for a spill during routine operations is rated high, indicating that an occurrence for this type of spill is probable. Spill rates from storage tanks and containers on pads is rated low; vehicle and equipment operations and maintenance are rated medium (BLM 2004). See Table 4-36 for an overview of potential project spills and their probability.

4.4.1.3 Probability of Very Large Spills

Very large spills greater than 1,000 gallons, but less than 100,000 gallons, have occurred on the North Slope. Information available about very large spills is based on historical evaluation of North Slope spill data, which includes at least nine spills greater than 1,000 barrels of either crude oil or process water from 1997–2008 (ADNR 2009). These range from the 2008 49,387 gallon (1,176 barrels) release of source water at Skid 50 (the sales oil pipeline's tie-in to the TAPS, near Pump Station 1) to the 995,400-gallon (23,700-bbl) release of seawater at the Drill Site 14 onshore oil production facility (ADNR 2009); both of these facilities are located in the East Operating Area of Prudhoe Bay. The 2006 Gathering Center 2 (GC-2) spill of approximately 212,252 gallons (5,054 bbls) of crude oil (Evans 2009) from a corroded pipeline located in the BPXA West Operating Area of Prudhoe Bay marked the largest onshore release of crude oil in the history of North Slope oil and gas production.

While the 2006 GC-2 spill was a very large spill of crude oil, throughout the history of the development of oil and gas resources on the North Slope, the majority of industry-related spills have averaged less than 10 gallons (0.238 barrel) with few spills larger than 42,000 gallons (10,000 barrels) (ADNR 2009). The MMS estimates that the mean number of large spills (greater than 42,000 gallons; 1,000 bbls) for the entire 20-year production life of the anticipated development associated with the Chukchi and Beaufort Sea Lease Sale Area is less than one and varies from 0.30–0.51 depending on the alternative (MMS 2008).

Additionally, while these do not include the 2006 GC-2 incident, the BLM and TAPS analyses of North Slope spills from January 1995–August 2003 document the low likelihood of large spills. The BLM analysis concluded that the rate of occurrence on average for hydrocarbon spills greater than 1,000 gallons is low or very low (BLM 2004). Spill data associated with Alaska North Slope (ANS) exploration and production (E&P) activities, including all North Slope oil wells, facilities, crude stabilization, and feeder pipelines (flow lines), available in BPXA and ADEC databases from 1977 to 1999 were also analyzed as part of the TAPS right-of-way renewal draft environmental report (2001). This analysis found that most spills are relatively small; about 84 percent of crude spills and 92 percent of product spills are less than 2 bbls (Figure 4-7).

The probability of a very large spill at the Project site is very low for all phases of construction, on the basis of the historical low rate of occurrence. See Table 4-36 for an overview of potential Project spills and their probability.

Large spills, such as those associated with pipelines and well blowouts, have the potential to be 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, surveillance measures–including regular ground inspection and overflights of the pipeline route–will be conducted to inspect for potential pipeline spills.

Table 4-36 identifies potential spill sources, the types of failures that may occur, estimates of spill sizes, and the project phase and spill risk that would occur in that phase.

4.4.1.4 Conditions Increasing Risk of Discharge

Conditions specific to the Project's drilling operations that potentially increase the risk of discharge, are summarized below.

- **Fuel Transfers:** Transfers will be required to refuel the drilling rig, camp, and on-site equipment.
- **High-pressure Drilling Operations:** Drilling into the high-pressure Thomson Sand gas reservoir requires specialized procedures.
- **Low Temperature:** Low temperature could cause some materials to become brittle or to contract differentially, increasing the risk of equipment failure. Fluids in pipes and tanks could freeze or become gelatinous, potentially rupturing pipes or tanks, and reducing the ability to pump fluids. Valves or other equipment could ice over or otherwise freeze, which would not allow them to operate as necessary to prevent discharges.
- **Weather Conditions:** Icy roads, white-out conditions, and prolonged periods of cold weather present obvious hazards to field operations.

4.4.1.5 Mitigating Measures to Prevent and Respond to Discharges

ExxonMobil employs mitigating measures to prevent and respond to discharges. Actions taken to eliminate or minimize identified risks include:

Fuel Transfers

Spills from these activities will be prevented or minimized by providing and following strict procedures, personnel training, and secondary containment devices that follow the BMPs of North Slope Operations presented in the *Alaska Safety Handbook* and *North Slope Environmental Handbook*. Oil storage tanks will be located within a secondary containment area with the capacity of 110 percent of the capacity of the largest tank. These secondary containment areas will be constructed of bermed/diked retaining walls and will be lined with impermeable materials resistant to damage and weather conditions. These areas will be kept free of debris, including excess accumulated rainwater and snow accumulation during winter season; they will be visually inspected by facility personnel. Fluid transfer checklists and North Slope manifests will be kept on file on site and in the Anchorage office. During fuel transfers from barges, additional ACS response vessels and personnel will be brought to the site in order to provide increased spill response capability. If a release to water or that could potentially reach water occurred, the additional spill response resources would quickly contain the spill, reducing the impact and providing great efficiency to recovery and cleanup operations.

High-pressure Drilling Operations

Drilling into the high-pressure Thomson Sand gas reservoir requires specialized equipment, materials, procedures, and training, as outlined in the drill plan and the Application for Permit to Drill that will be submitted to the AOGCC. During downhole operations, much of the discharge detection effort will center on well control with an emphasis on detecting wellbore influx (kicks) early. The primary control to prevent a discharge associated with a kick is the density of the drilling fluid in the wellbore. The fluid density and other critical parameters will be monitored closely 24 hours a day by drilling fluid specialists and trained members of the rig crew. The well control equipment will include several independent kick detection devices. The Standard Operating Procedure dictates that these systems are monitored 24 hours a day by rig crew members trained in well control to further ensure the timely recognition of and defense against potential spill events.

Low Temperature

Project facilities are specifically engineered to accommodate Arctic conditions. All non-standard operations require a pre-job safety meeting in which hazards are assessed. A risk assessment is done on those hazards and appropriate mitigation measures are identified to manage the hazards. The risk assessment will be led by the ExxonMobil on-site representative, with participation from the contractor toolpusher and any other appropriate personnel. The ExxonMobil on-site representative is responsible for making the final decision as to the level of risk.

Weather Conditions

ExxonMobil's strict enforcement of vehicle safety, speed limits, and the posting of warning signs assist in minimizing the potential for vehicular accidents that may result in a spill. North Slope weather conditions are divided into phases: Phase 1, 2, and 3 weather conditions are described below:

- Phase 1: Caution - reduced visibility. Travel is permitted using extreme caution. Reduce speed and be certain all equipment (e.g., radio and lights) is operating properly. Arctic gear is required.
- Phase 2: Restricted - convoy-only travel. Travel is permitted in convoys of two or more vehicles only. Radio communication between vehicles in the convoy is required.
- Phase 3: Closed - critical or emergency travel only. Travel will be by heavy-equipment convoy only.

If a spill occurs, there are several spill response resources at hand, including qualified on-site personnel, the Mutual Aid organization of North Slope operators, and Alaska Clean Seas. During a spill response the Incident Management Team (IMT) response organization structure is based on the Incident Command System. The IMT is organized and staffed to conduct a major oil spill response operation. Personnel on the IMT have appropriate training and work experience to provide guidance and make decisions essential for ensuring that oil spills, regardless of size and location are cleaned up in accordance with procedures that are environmentally acceptable. The IMT for the Project will be compatible with the state's oil spill response structure outlined in the Federal/State/Tribal Unified Plan for Alaska.

According to ExxonMobil standard protocols, the primary response action contractor, ACS, will be activated to stand by for spills that have the potential to be incidents that require additional resources beyond the onsite Spill Response Team until an assessment is performed. Once the assessment is complete, ACS will be either released or mobilized. For Tier II and III responses, ACS will provide labor and equipment resources from Point Thomson and Deadhorse to assist in spill containment and recovery. The North Slope operators coordinate with ACS to ensure that a reserve of trained staff is available for an extended spill response. Through the North Slope Mutual Aid Agreement, ExxonMobil also will have access to the North Slope Spill Response Team. If additional Response Action Contractor resources are required, they will be accessed through Master Service Agreements maintained by ACS. As necessary, ExxonMobil will use the resources of other North Slope operators through ACS, Mutual Aid, spill response cooperatives, and contractors. The Incident Commander has the authority to commit ExxonMobil and contractor resources available in the area to contain and clean up oil spills.

4.4.2 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 crude oils, which contain a smaller proportion of light fractions, therefore reducing persistence in the environment (see Section 4.4.2.2, Weathering).

4.4.2.1 Characteristics of Point Thomson Condensate

Condensate is a low density, low viscosity hydrocarbon liquid (at standard conditions) with a composition more similar to refined products such as kerosene or mineral spirits than crude oil. Like all petroleum-based products, condensate is comprised of many chemicals with differing physical and chemical properties. These include VOCs, semivolatile organic compounds (SVOCs), and heavier long-chain hydrocarbons. Unlike crude oil, condensate has a higher percentage of VOCs and a lower percentage of SVOCs and long-chain hydrocarbons. Since VOCs degrade more quickly in the environment than do less volatile compounds, this decreases the persistence of condensate in the environment compared to crude oil. Toxicity of petroleum mixtures is based on its chemical composition. Condensate contains a lower percentage of potentially toxic SVOCs such as polynuclear aromatic hydrocarbons (PAHs) than does crude oil, resulting in a lower relative toxicity. The higher degree of VOCs in the mixture indicates that weathering will also occur at a greater rate than crude oil, further reducing the inherent toxicity of the mixture once released into the environment. Additionally, concentrations of carcinogenic

VOCs such as benzene are lower in condensate than in either crude oil or refined products. As the VOCs weather, the percentage of less mobile, longer-chain hydrocarbons in the mixture increases. These longer-chain hydrocarbons are typically of lower toxicity than the more mobile and volatile components of the mixture. Therefore, the toxicity of both fresh and weathered condensate is more similar to mineral spirits than to crude oil.

4.4.2.2 Weathering

Oil begins weathering as soon it is exposed to the environment, with different oils having different weathering properties (Dickins et al. 2006). After a spill, its physical and chemical properties begin to be altered by the physical, chemical, and biological characteristics of the environment; this is called weathering (Huguenin 1996). The primary weathering processes include spreading, evaporation, dissolution, dispersion, emulsification, and sedimentation. These processes occur in the case of all discharges, but the rate and magnitude of each process depends on the specific oil and ambient environmental conditions. Figure 4-8 illustrates the relative importance of these primary processes over time.

The longer the oil remains exposed to environmental elements, the more weathered it becomes. Given the seasonal drilling restrictions, it is likely that any spills would occur during the winter, when they may be constrained by snow and ice. Conversely, oil on water spreads more quickly, and rapid intervention is critical (ADNR 2009).

The spreading of a slick, as well as the rates and extent of emulsification, evaporation, and biodegradation processes, are closely 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 characteristics over time. By convention, these properties are measured at a standard temperature and atmospheric pressure. However, the physical properties of an oil spill 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 that should be considered when comparing the known behaviors of crude and other oils with the Point Thomson condensate (Fingas et al. 1979).

- *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. Because 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 low 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 condensate at the Project site. 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 the Project 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. Lighter oils with low viscosities, such as the Point Thomson 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 by the Project is expected to volatilize rapidly 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, before volatilization, it may spread and emulsify more rapidly on water. However, in the coldest months when temperatures fall below -62.5 degrees Fahrenheit (°F) (-54 degrees Celsius [°C]), the condensate would likely be below the pour point and remain pooled at the ground surface. This value is the pour point of a similar gas/condensate (as reported by Gibson Energy ULC Natural Gas Condensate MSDS 2008).

5.0 MITIGATION MEASURES

Exxon Mobil Corporation (hereinafter ExxonMobil) has developed mitigation measures for the Point Thomson Project (hereinafter the Project). Mitigation measures are specific features, physical controls, and/or management measures - such as seasonal guidelines - that have been integrated into the Project design, construction, and operations. The measures are intended to avoid, minimize, or alleviate potential effects to the physical, biological, or human environment that may occur because of Project construction and/or operations. They are not a simple reiteration of requirements of permits, laws, and regulations. They represent a careful thought process undertaken during the design phase of the Project to identify actions that can be taken during design, construction, and operation to reduce or eliminate potential environmental effects.

Numerous Project mitigation measures have been incorporated into the design to this point. These measures have primarily been based on common North Slope practices, preliminary discussions with resource agency personnel, and conversations with local community members. However, as the Project design continues, additional Project-specific mitigation measures will likely be developed and incorporated into the design. This includes design phases such as Front End Engineering Design (FEED) and final design, and through consultation as part of the U.S. Army Corps of Engineers (USACE) Environmental Impact Statement process.

Input from local stakeholders, such as the communities of Kaktovik, Nuiqsut, and Anaktuvuk Pass, the North Slope Borough (NSB), Alaska Native tribal organizations and Alaska Native Claims Settlement Act (ANCSA) corporations will be particularly important during this process. ExxonMobil is committed to the integration of Traditional and Local Knowledge (TLK) during the design and eventual construction and operation of the Project. Individuals who use and/or have cultural ties to the Point Thomson area have and will be consulted and, where possible, their ideas incorporated into Project design, construction, and operation to mitigate Project effects to the physical environment, fish and wildlife subsistence resources upon which they are dependent, and the cultural importance of the area. Likewise, federal and state resource agency personnel will be consulted to ensure mitigation measures employed at Point Thomson are appropriate, given learnings from other current North Slope developments.

It is ExxonMobil's policy to conduct our business in a manner that is compatible with the balanced environmental and economic needs of the communities in which we operate. We look for opportunities to reduce our environmental footprint in the design phase of every new project, and we are committed to continuous efforts to improve environmental performance throughout our operations worldwide.

We have communicated our commitment in detail across all business lines and at all levels. ExxonMobil senior management has reinforced these expectations to all business lines through a corporate initiative called **Protect Tomorrow. Today**.

Through this directive it is our goal to achieve superior environmental performance and be recognized as an industry leader who operates responsibly everywhere we do business, and who, in doing so, will **Protect Tomorrow. Today**. Further, it is our vision that the Project will be viewed as the "Standard for Arctic Environmental Excellence".

Table 5-1 presents mitigation measures that have been incorporated into the Project, as well as measures that are best practices for North Slope development projects. Measures were evaluated for each development aspect of the Project, including design, drilling, construction, and operations. This format aligns with the Environmental Consequences chapter (Chapter 4) of this report. The table references the specific section of Chapter 4 that the mitigation measure addresses. All measures noted have been incorporated into the planning and/or design for construction and operation of the Project. As noted above, more measures may be added as the design matures and interactions with local community and agency personnel continue.

The first column of the table references a section of Chapter 4 followed by the mitigation measure or group of mitigation measures and the benefit or benefits of each measure or measures. The last column of the table notes if the measure is most applicable during design, drilling, construction, operations, or a combination of the four.

TABLE 5-1: MITIGATION MEASURES CONSIDERED FOR THIS PROJECT

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
General Best Practices to be employed during the life of the Project	• Maintain continual on-site environmental compliance presence during drilling, construction, and operation following ExxonMobil OIMS guidelines. This includes use of local subsistence monitors and marine mammal observers as agreed to during specific times and specific Project-related activities.	• Assure compliance with permit requirements and all applicable federal, state, and local laws. • Provide on-site environmental representation to address issues in a timely and efficient manner. • Prevent or minimize subsistence impacts.	Drilling Construction Operations
	• Establish an environmental and cultural awareness training program.	• Reduce potential for effects on fish and wildlife. • Reduce accidents and spill potential on tundra and sea ice. • Raise awareness of on-site personnel to the cultural importance and sensitivity of the local residents and area.	Drilling Construction Operations
	• Conduct permit compliance training with all employees.	• Assure compliance with permits, laws, and regulations. • Through compliance, reduce potential Project environmental impacts.	Drilling Construction Operations
	• Conduct periodic safety, security, health, and environmental (SSH&E) compliance assessments.	• Periodic independent performance assessment will yield continuous improvement in environmental performance and help detect and correct any deficiencies in these areas before a problem occurs. • Help ensure a safe and healthy working environment.	Drilling Construction Operations
	• Institute and enforce environmental compliance sensitivity training for construction and operations personnel.	• Reduce overall environmental impacts from the Project. • Use on-site environmental compliance presence for enforcement and monitoring.	Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Air Quality (Section 4.1.1)	• Design employs natural-gas-fired turbines as operations drivers for compressors which minimizes diesel-fired sources.	• Reduce the volume of air emissions. • Decrease the likelihood of bioaccumulation of industrial pollutants.	Design
	• Use dust control measures on gravel surfaces to reduce dust generation. • Strictly enforce vehicle speed limits.	• Minimize dust generation.	Construction Operations
	• Stacks are designed to an appropriate height above the tallest structure (except the communications tower).	• Increase dispersion of pollutants.	Operations
	• Use a Halon-free fire suppression system.	• Reduction in ozone depletion through use of non-Halon fire suppression system.	Construction Operations
Greenhouse Gases (GHG) (Section 4.1.5)	• Design includes the use of natural-gas-fired turbines to generate electrical power and electric motors to drive compressors which will minimize the use of diesel-fired sources. • Design includes waste heat recovery for process and module heat, thus eliminating gas fired heaters for these facilities and processes.	• Reduce GHG emissions.	Design Operations
	• Use efficient scheduling for transport of material and personnel to reduce number of vessel/vehicle trips.	• Reduce GHG emissions.	Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Water Quality (Section 4.1.3)	• Gravel mining and gravel placement will be during winter to the maximum extent practicable.	• Protect water quality. • Prevent increased turbidity. • Prevent damage to tundra.	Construction Operations
	• Pads, roads, and the airstrip have been designed to minimize blockage of natural surface water drainage, including properly spaced and designed culverts and bridges.	• Maintain natural drainage patterns and decrease incidence of culvert blockage.	Construction Operations
	• Locate gravel mine to minimize effects to freshwater resources and serve as a freshwater source for operations.	• Protect fish and aquatic fauna.	Design Construction Operations
	• Operational discharges have been eliminated to the greatest extent possible by designing injection wells as the primary disposal route. • A wastewater treatment system has been designed for wastewater discharge. During normal operations all wastewater disposal will be through the disposal well. In case of a disposal well upset, wastewater will be surface discharged in accordance with disposal permit.	• Protect tundra plants and habitats by minimizing surface discharges. • Reduce erosion. • Protect water quality by minimizing and managing wastewater discharges.	Design Drilling Construction Operations
	• Pads have been designed to minimize and control stormwater/snowmelt surface drainage. Pads are not graded to channelize water runoff, but designed such that water will seep through the gravel.	• Manage stormwater to prevent erosion and minimize vegetation impacts.	Design Operations
	• Employees will be exposed to continual improvement training in proper refueling methods that follow ExxonMobil OIMS. • Storage locations for fuels and other fluids have been designed with appropriate secondary containment systems. • Employees will be trained to properly handle and dispose of wastewater from secondary containment areas. • General refueling stations have been designed with appropriate secondary containment systems.	• Protect water quality by minimizing likelihood of spills and leaks. • Prevent accidental discharges to tundra. • Maintain on-site equipment and training to promptly respond to accidental events.	Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Water Quality (Section 4.1.3) (cont.)	• Gravel pads containing drilling or oil field facilities will be designed such that the 100-year water surface elevation associated with the 100-year riverine flood or storm surge, plus a suitable freeboard, is at or below the top of the pad.	• Reduce the risk of pollutants being washed off the gravel pad. • Reduce the risk of erosion of the pad.	Design
	• Vertical support members (VSMs) located in river channels and floodplains will be designed to accommodate the maximum scour depth that is likely to occur during a 200-year flood. • If ice floes are anticipated on a particular river, the VSM in that crossing will be designed to withstand the resultant potential forces.	• Reduce the risk of a product spill.	Design
	• Bridges will be designed such that the low chord of the bridge is above the 50-year water surface elevation plus a freeboard based on the potential for ice floes, waves, and the uncertainties involved in computing the design water surface elevation. • Bridge piers and abutments will be designed to accommodate the scour likely to occur in a 50-year or less frequent (i.e. higher return period) flood. • Culverts will be designed to withstand the anticipated loads, and to prevent erosion at the outlets.	• Reduce the risk of stream bed and bank erosion and bridge wash-out.	Design
	• The diversion channel between “24” Creek (the water supply reservoir) will be protected from erosion by designing the armor in the channel to be stable.	• Reduce the risk of erosion within “24” Creek.	Design Construction Operation

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Water Quality (Section 4.1.3) (cont.)	• The bottom of the diversion channel will be approximately 1 foot above the stream bottom.	• Maintain low flows in “24” Creek.	Design Construction Operation
	• A weir will be constructed within the diversion channel.	• Regulate when flows are allowed to enter the water supply reservoir.	Design Construction Operation
	• If it becomes necessary to move loads that are heavier than were anticipated over culverts, in the design, rig mats will be placed over the culverts and/or temporary bracing will be added to the inside of the culverts.	• Reduce the risk of culvert collapse, erosion, and fish passage restrictions.	Operations
Tundra/ Wetlands (Section 4.2.2)	• Gravel pad footprints have been designed to minimize footprint while still meeting operational and safety requirements. • In-field access road width is designed using 2:1 side slopes.	• Reduce acres of tundra physically covered by gravel.	Design
	• Ice roads and pads will be used for initial construction and seasonal access.	• Reduce gravel infrastructure through seasonal use of ice roads and pad.	Design
	• No gravel road will connect Point Thomson to oil fields located to the west.	• Reduce gravel use and project footprint. • Reduce access to the Project area, thus reducing potential added pressure on local resources.	Design
	• Utilize existing gravel pads to reduce new gravel footprint, where practicable.	• Use of existing pads reduces the necessity of impacting additional tundra and for additional gravel extraction and placement, thus reducing overall Project footprint.	Design
	• Conduct major construction efforts in winter for in-field roads, pads, pipeline, and airstrip.	• Protect permafrost from degradation. • Protect habitat and minimize wildlife disturbance. • Prevent erosion.	Construction

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Tundra/ Wetlands (Section 4.2.2) (cont.)	• On the basis of hydrological studies, gravel mine, roads, stream crossings, and minor drainages have been designed to reduce alterations in surface water drainage patterns. • Culvert requirements for in-field roads have been designed to reduce alterations to surface water drainage patterns. • Operations crews will prevent icing/blockage of culverts and manually remove ice when required. • Inspect to assure proper flow is occurring.	• Protect tundra from inundation by water to protect permafrost and vegetation. • Maintain existing drainage flow patterns.	Design Construction Operations
	• Dust control measures will include dust control applied to roads and pads (water or other approved chemicals) and enforcing speed limits.	• Protect vegetation through reduction of the dust shadow.	Construction Operations
Fish and Fish Habitat (including anadromous, freshwater, and marine) (Sections 4.1.3, 4.1.4, and 4.2.3)	• Work will be limited in streams in known spawning areas and will not be allowed during fish spawning. • Major construction efforts will be in winter for in-field roads, pads, pipeline, and airstrip.	• Minimize direct effects/mortality of fish.	Construction
	• Project design has minimized obstructions to fish migration because of roads and stream crossings through proper siting and culvert and bridge design. • Normal ice break-up will be facilitated by removing blockages in culverts and breaching ice roads as needed	• Protect ecosystem function and connectivity. • Maintain fish movement up- and downstream.	Design Operations
	• Winter water withdrawal in fish-bearing water sources is limited to permitted quantities (Note: 15 percent for anadromous fish streams; 30 percent for non-anadromous fish streams).	• Protect fish overwintering habitat.	Design Drilling Construction Operations
	• The gravel for roads and pads will be mined during winter only and according to approved mining plan. • Avoid areas that could be used by overwintering fish (pools) during ice road construction.	• Maintain optimal fish habitat. • Provide adequate anadromous, freshwater, and marine fish passage. • Maintain overwintering habitat.	Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Fish and Fish Habitat (including anadromous, freshwater, and marine) (Sections 4.1.3, 4.1.4, and 4.2.3) (cont.)	• Stream banks will not be cut for access; ice or snow ramps will be used. • Streams will only be crossed (tundra travel) where solidly frozen. Stream crossings will target areas that have naturally frozen to the stream bottom.	• Provide for good stream bank stabilization. • Prevent long-term alteration of habitat.	Construction Operations
	• Operate marine vessel traffic in a manner that will avoid spills to the marine environment.	• Prevent spills from entering the marine environment.	Drilling Construction Operations
Wildlife and Habitat (Section 4.2)	Caribou and Muskoxen • Pipelines are designed to be a minimum of 7 feet (2.1 meters) high (from bottom of pipe to the surface of the ground or the bottom of a pipe dampening structure to the ground surface if pipe dampener is hung below the pipe). • In-field pipelines and roads have been designed to be aligned with a minimum 500-foot (152.4 meters) separation. • The Central, East, and West pads will be constructed with rounded corners. • Major construction efforts are planned for winter for in-field roads, pads, pipeline, and airstrip.	• Minimize impacts to important habitat/use areas and disturbance to migrating caribou and muskoxen. • Minimize restrictions to subsistence hunters' movements (safe for snowmachine operation).	Design Construction
	• Vehicle speed limits will be enforced within the Project area.	• Minimize vehicle collisions with caribou and muskoxen.	Construction Operations
	• Helicopter routes and schedules have been designed to minimize wildlife disturbance. • ExxonMobil will institute a no-hunting policy for site workers. • ExxonMobil will prepare and enforce a wildlife interaction plan.	• Avoid disruption of subsistence resources. • Avoid disruption of subsistence hunting.	Design Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Wildlife and Habitat (Section 4.2) (cont.)	Birds • Water removal from freshwater lakes (except the water source lakes) used by nesting waterfowl will be limited during the summer.	• Reduce the potential for limiting or reducing nesting habitat through littoral zone depletion.	Operations
	• Structures are designed to minimize nesting opportunities for birds.	• Prevent population increases in scavenging birds like gulls and ravens.	Design Construction
	• Careful design considerations were given to facility lighting (light hoods to reduce outward-radiating light). • The height of structures was reduced during design as much as practicable.	• Reduce the potential for bird strikes.	Design Operations
	Other Mammals Including Grizzly Bear and Foxes • Wastes will be managed such that it is unavailable to bears and foxes. • Feeding of all wildlife is prohibited by ExxonMobil policy. • Bear-proof dumpsters will be used at all Project locations. • Facilities have been designed to reduce the potential denning sites for foxes and hiding places for bears.	• Prevent food habituation of wildlife species. • Prevent human habituation of bears and foxes.	Drilling Construction Operations
	• Vehicle speed limits will be strictly enforced within Project area.	• Minimize vehicle collisions with bears and foxes.	Construction Operations
	• A specific bear interaction plan will be implemented to raise awareness and train employees for proper response during a bear encounter.	• Prevent human-bear interaction which can lead to bear or human mortality.	Construction Operations

Issue/Resource/ Report Section	**Mitigation Measures**	**Benefit**	**Project Development Aspect**
Marine Mammals (Section 4.2.5)	Cetaceans (Whales and Porpoises) • During fall and spring migration, vessel routes, to the extent practicable, will be inside the barrier islands and helicopter flights will be limited to overland routes to minimize disturbance to migrating whales. • Flights over open water from spring to fall will be flown above 1,500 feet (457 meters) to minimize disturbance to whales, unless safety considerations require flights at a lower altitude. • Marine mammal observers will be on each vessel or convoy to observe and maintain a record of marine mammal encounters. • Vessels will alter speed and course to avoid crossing in front of a whale encountered along the transportation route whenever possible.	• Minimize disturbance to whales. • Prevent alteration of subsistence activities. • Document marine mammal encounters and animal reaction.	Drilling Construction Operations
	Pinnipeds (Seals) • Aircraft will fly designated routes at designated altitudes based on consultation with federal, state, and local agencies, and in conformance with health and safety practices.	• Minimize disturbance to pinnipeds, especially during pupping and molting periods.	Drilling Construction Operations
	• To the extent practicable, sea-ice roads will be constructed on grounded ice (not seal habitat). • Begin sea-ice road construction as early as possible, before pupping season.	• Eliminate seal concerns by constructing the road outside of seal habitats.	Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Threatened and Endangered Species (Section 4.2.7)	Spectacled and Steller's Eiders • Major construction will be in winter for in-field roads, pads, pipeline, and airstrip.	• Eliminates disturbance to the birds during the spring and summer nesting season.	Construction
	Bowhead Whales • During fall and spring migration, vessel routes will be inside the barrier islands to the extent practicable and helicopter flights will be limited to overland routes to minimize disturbance to migrating whales. • Any flights over open water will be flown above 1,500 feet (457 meters) to minimize disturbance to whales, unless safety considerations require flights at a lower altitude. • Vessels will alter speed and course to avoid crossing in front of a bowhead whale encountered along the transportation route whenever possible. • Marine mammal observers will be on each vessel or convoy to observe and maintain a record of marine mammal encounters. • ExxonMobil will execute a Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission (AEWC).	• Minimize disturbance to whales. • Prevent alteration of subsistence activities. • Document marine mammal encounters and animal reaction.	Drilling Construction Operations
	Polar Bears • Develop and implement a polar bear interaction plan. • Coordinate yearly polar bear surveys with USFWS. • The Point Thomson facility will be designed to reduce polar bear and human interactions.	• Minimize the potential for a "take". • Maximize human safety.	Design Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Threatened and Endangered Species (Section 4.2.7) (cont.)	• ExxonMobil, working with the USFWS, will locate and avoid historic polar bear denning areas. • Each year of ice road development, ExxonMobil will work with the USFWS to use Forward Looking Infrared Radar (FLIR) technology and other potential or promising technologies to locate polar bear dens along ice road routes. • Polar bear dens will be avoided by 1 mile, even if it means moving an ice road after construction.	• Prevent den abandonment by denning females with cubs.	Drilling Construction Operations
	• Wastes will be managed to avoid attracting polar bears. • Bear-proof dumpsters will be used throughout the Project site.	• Prevent polar bear food conditioning and human habituation.	Drilling Construction Operations
Subsistence (Section 4.3.3)	• Many of the mitigation measures described above for Wildlife and Habitat, Marine Mammals, and Threatened and Endangered Species.	• Minimize the potential effects on subsistence resource uses in all areas of Alaska National Interest Lands Conservation Act (ANILCA) concern.	Drilling Construction Operations
	• Major construction efforts will be in the winter for in-field roads, pads, pipeline, and airstrip.	• Protect subsistence resources as construction takes place when few subsistence resources are in or adjacent to the Project area.	Construction

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Subsistence (Section 4.3.3) (cont.)	• ExxonMobil will implement a policy to prohibit hunting by construction and operations staff, and will only allow fishing with a required state license, following state regulations and not in conflict with subsistence activities. • Subsistence resource sensitivity training will be required for construction and operations personnel. • ExxonMobil is consulting with residents of Kaktovik, Anaktuvuk Pass, and Nuiqsut, and with the NSB about facility location, design, construction, and operations to avoid and minimize potential adverse effects on subsistence activities. • ExxonMobil will employ a subsistence representative on-site during project construction (2011–2014).	• Protect subsistence resources and activities. • Open lines of communication with local communities to share resource and Project construction and operation information. • Designs are modified to reduce effects on subsistence resources based on input from the subsistence community.	Design Construction Operations
	• The outer insulating jacket of the gathering and export pipelines will be a flat, grey metallic surface to avoid a bright and shiny effect. This avoids a bright, reflective barrier and reduces the visual impact on hunter and caribou alike. • Pipelines wall thickness will be checked to ensure that pipelines are resistant to damage from accidental bullet strikes from coastal subsistence hunting. In consultation with Kaktovik, consideration will be given to additional wall thickness to accommodate hunter use in bays and inlets which encroach in the pipeline ballistics safety corridor. • Reflector tape or lighting will be placed on the barge mooring dolphins.	• Minimize potential for interruptions to caribou subsistence hunting opportunities. • Minimize the potential for collisions with the barge mooring dolphins during both summer and winter travel.	Design Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Subsistence (Section 4.3.3) (cont.)	• Vessel traffic will be routed inside the barrier islands to minimize disturbance to subsistence activities. • Offshore activities, such as barge traffic, will be coordinated with subsistence communities. • ExxonMobil will execute a CAA with the AEWC. • ExxonMobil will enlist the help of Inupiat marine mammal observers and subsistence monitors to observe and maintain a record of encounters and to help minimize potential interference with subsistence activities.	• Avoid conflicts with subsistence whaling activities.	Construction Operations
Cultural Resources (Section 4.3.2)	<u>Archaeological Sites</u> • All Project features have been designed to avoid identified archaeological sites. • Residents of Kaktovik, Nuiqsut, and the NSB will be consulted to obtain and incorporate local information about important traditional and historical sites. • ExxonMobil will maintain confidentiality of site locations. • Cultural resource sensitivity training will be mandatory for all construction and operations personnel. • All disturbing activities will be stopped in the direct vicinity of previously unidentified cultural resources. The discovery will be reported to on-site supervisory personnel and the State Historic Preservation Office (SHPO) and the NSB.	• Protect known cultural resources in the Point Thomson area by maintaining site buffer zones. • Comply with federal, state, and borough regulations and permit stipulations.	Design Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Cultural Values (Section 4.3)	• ExxonMobil is consulting with residents of Kaktovik, Nuiqsut, Anaktuvuk Pass, and the NSB to obtain, understand, and respond to community input about cultural values, practices, and historical and contemporary use of the Point Thomson area. • ExxonMobil will communicate with communities to keep them informed of Project developments though regular meetings and gatherings. • Such community meetings will be scheduled to avoid key subsistence activities. • ExxonMobil will provide regular feedback to the residents of Kaktovik, Nuiqsut, Anaktuvuk Pass, and the NSB regarding how suggestions and recommendations have been addressed and incorporated in Project design, location, construction, and operations.	• Maintain positive relationships with local communities. • Design Project to avoid conflicts with local communities. • Prevent interference with subsistence activities. • Incorporate local recommendations to ensure successful project design, construction, and operation.	Design Drilling Construction Operations
	• The Project has been designed to minimize potential adverse visual effects from lights, flaring, structural profile, and facility color. • Facility design includes no permanent road connecting the Project to a state road system or other North Slope facilities and therefore the Project will not result in an increase in access to non-residents.	• Maintain positive relationships with local communities. • Minimize negative changes to local culture and subsistence activities.	Design Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Cultural Values (Section 4.3) (cont.)	• Point Thomson has been designed for zero discharge of drilling wastes. • Corrosion-resistant alloy has been selected for use for the gathering lines. • The sales pipeline has been designed with leak detection, monitoring, and operating procedures. • Pipeline design includes pigging facilities for internal monitoring and internal corrosion protection system. • The pipeline will be designed to reduce the possibility of an inadvertent bullet penetrating the pipeline. • Use on-site fuel gas for power when it becomes available. (Note: diesel will be required for back-up.)	• Reduce the potential for spills and leaks.	Design Drilling Construction Operations
Spill Prevention (Section 4.4)	• ExxonMobil will maintain adequate spill response equipment and personnel to respond to terrestrial and marine spills. • Personnel will be trained in acceptable refueling procedures at specified locations for refueling.	• Reduction in the severity of spill effects by maintaining adequate spill response equipment and training.	Drilling Construction Operations
	• During construction, fuel storage and transfer locations will be located away from river crossings and secondary containment will be used at all temporary fuel storage and transfer locations. • Drip pans and liners will be mandatory in accordance with ExxonMobil policies and procedures during refueling and vehicle maintenance procedures.	• Minimize risks to terrestrial and marine environments by reducing the potential for spills and leaks.	Design Drilling Construction Operations

Issue/Resource/ Report Section	Mitigation Measures	Benefit	Project Development Aspect
Recreational and Visual Effects (Sections 4.3.6 and 4.3.7)	• Designs reduce indirect lighting to the extent practicable. • Lights face to the center of the facility and are shielded to the extent practicable. • The structural profile has been reduced where practical. • Natural color schemes that blend with environment have been incorporated into the design where practicable and on paintable structures. • Outer insulating jackets of the gathering and export pipelines will be a flat, grey metallic surface to avoid a bright and shiny effect (see similar comment in Subsistence).	• Lessen viewshed impact of Project footprint. • Reduce concerns from users of Alaska National Wildlife Refuge (the Refuge). • Reduce impacts to subsistence hunting.	Design Construction Operations
	• ExxonMobil will develop company policies for employees' recreation activities, particularly regarding off-pad access.	• Minimize site impacts and social impacts to recreation activities.	Design Drilling Construction Operations
	• ExxonMobil will include noise reduction technology where practicable (e.g. mufflers, building insulation).	• Minimize noise attenuation.	Design

Notes:
ADEC = Alaska Department of Environmental Conservation
AEWC = Alaska Eskimo Whaling Commission
ANILCA = Alaska National Interest Lands Conservation Act
CAA = Conflict Avoidance Agreement
FLIR = Forward Looking Infrared Radar
GHG = greenhouse gases
NSB = North Slope Borough
OIMS = Operations Integrity Management System
Refuge = Alaska National Wildlife Refuge
SHPO = State Historic Preservation Office
SSH&E = safety, security, health, and environment
USFWS = U.S. Fish and Wildlife Service
VSM = vertical support member

6.0 CUMULATIVE EFFECTS

6.1 INTRODUCTION

The National Environmental Policy Act (NEPA) requires an analysis of cumulative effects for major federal actions subject to an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The Council on Environmental Quality (CEQ) regulations for implementing NEPA defines cumulative effects as:

> *"the effect on the environment which results from the incremental effect 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" (Title 40, Code of Federal Regulations, Part 1508.7) (40 CFR 1508.7).*

This chapter of the Environmental Report (ER) follows the CEQ guidelines for analysis of cumulative effects. The objective of this chapter is to provide information to assist agencies in assessing the potential contribution to cumulative effects of the proposed Point Thomson Project (hereinafter the Project) as part of compliance with NEPA. Chapter 6 presents an analysis of potential cumulative effects associated with construction and operation of the Project.

Suggestions and recommendations received during pre-application consultation, from local stakeholders such as the communities of Kaktovik and Nuiqsut, North Slope Borough (NSB), Alaska Native tribal organizations, and Alaska Native Claims Settlement Act (ANCSA) village corporation organizations were considered during analysis of potential cumulative effects. These include the contribution of the Project to potential cumulative effects on the physical environment, fish and wildlife, subsistence resources on which they are dependent, and the cultural resources of the area. Likewise, comments received from state and federal resource agency personnel during the pre-application consultation process were also utilized in analyzing potential cumulative effects associated with the Project as appropriate.

6.2 DEFINITION OF TERMS

The following terms are used throughout this document to discuss effects:

- **Direct Effects** – Caused by the action and occurring at the same time and place (40 CFR 1508.8).
- **Indirect Effects** – Defined as effects "caused by an action and are later in time or farther removed in distance but are still reasonably likely. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8). Indirect effects are caused by the Project, but do not occur at the same time or place as the direct effects.

- **Cumulative Effects** – Additive or interactive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions (40 CFR 1508.7). Interactive effects may be either *countervailing* – where the net cumulative effect is less than the sum of the individual effects, or *synergistic* – where the net cumulative effect is greater than the sum of the individual effects.

  This analysis focuses on reasonably foreseeable cumulative effects issues, rather than on speculative impact relationships. Direct effects pertain to the proposed action and alternatives only, while cumulative effects pertain to the additive or interactive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. In addition, the CEQ has stated that cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.
- **Reasonably Foreseeable Future Actions (RFFAs)** – This term is used in concert with the CEQ definitions of indirect and cumulative effects, but the term "reasonably foreseeable" itself is not further defined in the regulations. For this analysis, RFFAs are those that are likely or reasonably certain to occur. Often, they are based on publically available documents such as existing plans, permit applications, or announcements. Actions may also be reasonably foreseeable if they are uncertain in some aspects but probable. Potential actions which require speculation or are not likely to occur are not considered reasonably foreseeable.

6.3 SCOPE OF ANALYSIS

The general spatial scope of this analysis is the North Slope of Alaska between U.S.-Canada border and Barrow, primarily to evaluate any potential socioeconomic effects to the communities within this region, as well as any potential interaction between barge traffic (from Barrow eastward) and the fall whale migration and associated subsistence harvest. When this spatial scope is not applicable to a given resource, a relevant geographic sub-area is defined in the analysis.

The temporal scope or time frame for this cumulative effects analysis to capture past actions begins with the initial discovery of Prudhoe Bay in 1968. Although local people in the region have used oil shales and seepage tars before recorded history and the National Petroleum Reserve No. 4 was created in 1923, oil and gas development with the types of effects similar to those of the Project did not begin until the Prudhoe Bay discovery. For some resources, relevant data may precede that date or not be available until more recently, in which case the time frame for past/present effects is defined in the cumulative effects section for each resource. RFFAs considered in the cumulative effects analysis consist of projects, actions, or developments that can be projected to occur over the next 10 years (from 2010 - 2020) and that are likely to affect the resources described. The process for determining which RFFAs are considered in this analysis is presented in Section 6.6.

6.4 STEPS FOR IDENTIFYING CUMULATIVE EFFECTS

The methodology for cumulative effects assessment in this study consists of the following steps:

- Identify characteristics and trends within the affected environment that are relevant to assessing cumulative effects of the proposed action (i.e., the Project). This information is presented in Chapter 3, Affected Environment.
- Describe the potential direct and indirect effects of the proposed action. This information is presented in Chapter 4, Environmental Consequences.
- Define the geographical boundaries or region of influence (ROI) within which potential effects on particular resources will be analyzed. This information is presented within this chapter for each resource evaluated.
- Identify past, present, and RFFAs such as other development, other types of human activities, and natural phenomena that could have additive or synergistic effects. Past actions must be evaluated to determine whether there are lingering effects that may still result in synergistic or incremental impacts when combined with the proposed action. The CEQ guidelines advise that the cumulative effects analyses assess RFFAs. It is important to note that only resources affected by the proposed action will be included in the cumulative effects assessment.
- Screen all of the direct and indirect effects with regard to external factors to capture those effects that are potentially cumulative in nature. Both adverse and beneficial effects of external factors are assessed and then evaluated in combination with the direct and indirect effects to determine if there are contributions to cumulative effects. Evaluation of cumulative effects hinges on the results of direct and indirect effects analysis. Thus, if there is no direct or indirect effect of the Project on a given resource, there would be no cumulative effect.
- Evaluate the intensity (magnitude and duration) and extent of the potential cumulative effects using criteria established for direct and indirect effects and the relative contribution of the proposed action to cumulative effects. The intensity and extent of the potential effects are evaluated considering: 1) the sensitivity of the resources to the anticipated change and 2) the carrying capacity or sustainability of the resource.
- Provide the rationale that led to the conclusions regarding cumulative effects, citing evidence from the peer-reviewed literature and quantitative information where available. The level of effect is based on reasonable assumptions. See Section 6.4.2 for key assumptions.

The advantages of this approach are that it closely follows 1997 CEQ guidance (CEQ 1997), employs an orderly and explicit procedure, and provides the reader with current and relevant information necessary to make an informed and independent judgment concerning the validity of the conclusions.

6.4.1 Effects Criteria and Assessment

Assessment of potential environmental consequence often considers both the context in which the action will occur and the intensity of the action. The context is typically composed of the extent of the effect (geographic extent or extent within a species, ecosystem, or region) and any special conditions, such as endangered species status or other legal ramifications. The intensity of an effect is the result of its magnitude and duration. Actions may have both adverse and beneficial effects on a particular resource. A component of both the context and the intensity of an effect is the likelihood of its occurrence. The effects analysis should be conducted in a consistent manner based on standardized effect definitions. These definitions are presented below in Table 6-1.

TABLE 6-1: EFFECTS CRITERIA

Impact Component	None	Minor	Moderate	Major
MAGNITUDE	Effects on resource may occur as a result of project activities, but are not measurable.	Effects on resource are measurable, and individually may or may not require avoidance or minimization to mitigate that effect.	Noticeable change in resource would occur and this change would alter the condition or appearance of the resource. Avoidance or minimization to mitigate the effect would be required.	Substantial effect or change in resource would occur that is easily defined, highly noticeable, and measurably alters the condition or appearance of the resource. Avoidance or minimization to mitigate the effect would be required.
EXTENT	None	**Localized** – Effect would occur only at this alternative site or its immediate surroundings, and would not extend into the region.	Effect would affect the resource on a **regional** level or in the region as a whole, extending well beyond the immediate alternative site.	Effect on the resource on a **national** level, extending well beyond the region as a whole.
DURATION	None	**Temporary** – Effect would occur only during construction. After construction, the resource conditions would return to pre-construction conditions.	**Short-term** – Effect would extend beyond the time of construction, but would not last more than two years.	**Long-term** – Effect would likely last more than two years and may continue beyond the lifetime of the Project.

6.4.2 Key Assumptions

This section identifies several key assumptions that are used in the evaluation of cumulative effects of the Project.

- The cumulative effects analysis addresses the relative contribution of Project direct and indirect effects to cumulative effects, but generally does not reach conclusions on the overall significance of cumulative effects.
- The spatial scope of analysis generally focuses on the area between Barrow and the U.S.-Canada border, but is defined specifically for each research category. For socioeconomic effects, the Project can contribute to beneficial economic effects in the NSB and State of Alaska.
- Experience and judgment of subject matter experts were applied to identification of RFFAs (see Section 6.5). For example, a natural gas sales transmission pipeline from Point Thomson to Prudhoe Bay, and from Prudhoe Bay to the U.S.-Canada border is

reasonably foreseeable. However, while further seismic exploration and drilling in the eastern Beaufort Sea is seen as reasonably foreseeable, development and production is not until the results of exploration are known.

- Observed trends in climate and other physical environment characteristics have occurred and are expected to continue to some degree; the interaction between Project direct and indirect effect and these observed trends is addressed in various subsections of Section 6.7.

6.5 RELEVANT PAST AND PRESENT EXTERNAL ACTIONS WITHIN THE PROJECT AREA

An inventory of past and present external actions within the region is used as the basis for identifying actions relevant to this ER. A list of relevant past and present actions considered not only includes activities associated with oil and gas development, but other non-oil and -gas activities as well. Non-oil and -gas activities considered in the cumulative effects analysis may include: 1) human-controlled activities or actions such as subsistence, commercial fishing (Colville River), tourism and recreation, military activities (primarily former Distant Early Warning [DEW] line sites), or community development projects and (2) naturally occurring events such as trends in climate and other physical characteristics. These actions are shown in Table 6-2. Past and present actions and activities were identified using several sources: the Alaska Department of Commerce, Community, and Economic Development (DCCED) Website; peer-reviewed literature; EISs for other projects in the area and the Beaufort and Chukchi Seas Lease Sales; and North Slope resource studies. Subject matter expert contributors to this ER also assisted in identifying related external actions. For each resource presented in Sections 6.7 - 6.9, analysts provide a general description of the category of actions considered in their analysis.

6.6 RFFAS WITHIN THE PROJECT AREA

Evaluating future effects on resources in the Project area, independent of the Project, is essential to a cumulative effects analysis. The future actions and conditions that may cause effects must be reasonably foreseeable (actions that are likely or probable) rather than those that are simply possible. Judgments concerning the probability of future effects must be informed rather than based on speculation.

As with past and present actions, relevant RFFAs considered include non-oil and -gas activities (e.g., community development projects) as well as those associated with oil and gas development. Although many community, borough, state, or industry development plans may list dozens of projects, this is not always a strong indication that a project will be constructed. For this reason, a process was developed to identify which actions should be considered probable on the basis of the status of the Project as of fall 2009. Analysts considered a combination of criteria to determine if a proposed action is probable, including whether the action: 1) is located within the Project ROI; 2) is currently funded; 3) is permitted or is currently active; or 4) is listed as a top priority in community, borough, state, or national plans. For example, an action that has an existing footprint (i.e., development area physically established), and/or permits or applications submitted, would be considered reasonably foreseeable. Several actions were dismissed from further analysis because insufficient information existed to determine: 1) when the action might occur, 2) what resources the action might affect, or 3) whether petroleum exploration activities will result in a decision to develop the resource.

6.6.1 RFFAs Carried Forward for Analysis

Table 6-2 provides a list of the RFFAs that have been identified for the analysis, and are shown in Figure 6-2. These projects have been determined from reviews of adopted plans, ERs, EISs, the Alaska DCCED Website; peer-reviewed literature; EISs for other projects in the area and the Beaufort and Chukchi Seas Lease Sales; and North Slope resource studies. It is important to note that actions carried forward for analysis must be considered probable, not just possible. Therefore, only those actions that would be located within the ROI and with high probability of occurring have been included for analysis. The RFFAs considered in the cumulative effects analysis are shown in Table 6-2. Not all of these activities will have a nexus with every resource discussed in Sections 6.7 – 6.9. For example, many of the smaller oil fields in the Prudhoe Bay Kuparuk area will continue operating into the future, but could have a cumulative effects relationship to the Project primarily with lands use and socioeconomic characteristics.

Many of the past, present, and RFFAs are similar in either their purpose (i.e., tourism, exploratory drilling, construction, etc.), or their effects (i.e., increased air pollution). Therefore, for the purposes of this analysis, these actions have been sorted into categories accordingly. Please refer to Chapter 3 of this report for additional detail for many of the activities listed in Table 6-2 below.

In addition to the RFFAs referenced above, trends in climate and related physical environmental characteristics can be expected to continue and are reasonably foreseeable. They are not specifically an action, but are addressed in appropriate sections of this chapter.

TABLE 6-2: PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS CONSIDERED IN THE CUMULATIVE EFFECTS ANALYSIS

Category	Area	Project	Past	Present	Future
Community Development/Capital Projects	Barrow	Various	X	X	X
	Kaktovik	Various	X	X	X
	Nuiqsut	Various	X	X	X
Military	DEW Line Sites	Barter Island	X	X	X
		Bullen Point SRRS	X		
		Flaxman Island SRRS	X		
Oil/Gas Development	Badami	Badami	X		X
	Colville River	Alpine (CD-1, CD-2)	X	X	X
		Alpine West (CD-5)	X		X
		Fjiord (CD3)	X	X	X
		Nanuq (CD4)	X	X	X
	Greater Mooses Tooth (GMT) (NPR-A)	GMT 1 (aka Alpine Satellite CD-6)	X		X
		GMT 2 (aka Alpine Satellite CD-7)	X		X
	Duck Island	Endicott	X	X	X
		Liberty	X	X	X
		Eider	X		
		Sag Delta North	X		
	Kuparuk River	Kuparuk	X	X	X
		Palm (DS 3S)	X	X	X
		Meltwater	X	X	X
		Tabasco	X	X	X
		Tarn	X	X	X
		West Sak	X	X	X
	Milne Point	Milne Point	X	X	X
		Cascade	X	X	X
		Sag River	X	X	X
		Schrader Bluff	X	X	X
		Ugnu	X	X	X
	Northstar	Northstar	X	X	X
	Prudhoe Bay	Prudhoe Bay	X	X	X
		Aurora	X	X	X
		Borealis	X	X	X
		Lisburne	X	X	X
		Midnight Sun	X	X	X
		N. Prudhoe Bay	X	X	X
		Niak IV-SR	X	X	X
		Niakuk	X	X	X
		Western Niakuk	X	X	X
		Orion	X	X	X
		Polaris	X	X	X
		Point McIntyre	X	X	X

Category	Area	Project	Past	Present	Future
		Raven	X	X	X
		West Beach	X	X	X
	Oooguruk	Oooguruk	X	X	X
	Nikaitchuq	Nikaitchuq	X	X	X
	Point Thomson	Point Thomson potential expanded gas cycling			X
Oil/Gas Exploration	Beechey Point	North Shore	X		X
		Gwydyr Bay	X		X
		Pete's Wicked	X		
	Eastern Beaufort Area	Flaxman Island	X		
		Camden Bay (Hammerhead /Sivulliq)	X		X
		Kuvlum	X		
		Mikkelson	X		
		Stinson	X		
	Point Thomson Area/ Eastern North Slope	Slugger	X		
		Sourdough	X		
		Yukon Gold	X		
		Kavik	X		
		Kemik	X		
		ANW Refuge private inholdings	X		
Oil/Gas Transportation	Carrier Pipelines	Various	X	X	
	Fuel Transfer (barges, etc.)	Various	X	X	X
	Point Thomson Sales Gas Pipeline				X
	Alaska Gas Pipeline	Various			X
	TAPS	Various	X	X	X
Recreation/Tourism	The Refuge	Various	X	X	X
	North Slope (Kaktovik)	Various	X	X	X
	Beaufort Sea cruises	Various		X	X
Sport Hunting/Fishing	ANW Refuge	Various	X	X	X
	Brooks Range/Dalton Highway	Various	X	X	X
	Kaktovik Area	Various	X	X	X
Subsistence	North Slope	Various	X	X	X
Transportation	Air Fields and Strips	Various	X	X	X
	Dalton Highway	Various	X	X	X
	Marine Vessel Traffic	Various	X	X	X

Notes:
ANW Refuge = Arctic National Wildlife Refuge
DEW = Distant Early Warning
GMT = Greater Mooses Tooth
NPR-A = National Petroleum Reserve Alaska
SRRS = Short-range Radar Station
TAPS = Trans Alaska Pipeline System

6.6.2 RFFAs Not Carried Forward for Analysis

Proposed future actions that have no nexus with the Project, are not located within the ROI, or have a low probability of occurring have been eliminated from this analysis. A list of proposed future actions that were eliminated from the analysis is presented in Table 6-3. This includes commercial fishing activities in the Colville River and Beaufort Sea (no nexus given that there are no project effects on fish), community and military development projects outside the ROI, and onshore and offshore oil and gas projects with no known plans or proposals for exploration and development.

In particular, three potential future actions in the vicinity of Point Thomson have been eliminated from further analysis: development of Sourdough, Yukon Gold, and other small prospects south of Point Thomson, production of petroleum resources in Camden Bay (Hammerhead and Sivulliq prospects), and exploration and production petroleum resources in the Arctic National Wildlife Refuge (hereinafter Refuge). Exploration activities associated with Sourdough and Yukon prospects have not been pursued due to apparent challenges with reservoir characteristics and economic feasibility. At this time, there are no known or announced plans for further exploration and production of these prospects.

Exploration activities (drilling and additional seismic exploration) for the Hammerhead and Sivulliq prospects in Camden Bay have been announced and are awaiting permit approval, and are considered reasonably foreseeable (see previous discussion). However, until the results of exploration are known and the feasibility of development has been established, production and how it would occur is not predictable or reasonably foreseeable at this time.

Oil and gas exploration has occurred on private lands within the Refuge, but no further exploration plans have bee announced. Exploration and production on public lands within the Refuge is currently not allowed under current law, and would require Congressional approval to occur. Over the past two decades, several attempts were made to pass legislation to allow expanded exploration and production within the Refuge, none of which were successful. No current legislation is pending, and there are no specific plans or proposals for exploration for and production of oil and gas within the Refuge.

TABLE 6-3: RFFAS NOT CARRIED FORWARD FOR ANALYSIS

Category		Past	Present	Future	Rationale
Commercial Fishing					No Project dock; no nexus
Beaufort Sea		Whaling	X		
Colville River			X		
Community Development/Capital Projects					
Atqasuk			NA		Outside impact area
Deadhorse		X	X	X	No nexus with project area resources or activities
Military					
DEW Line Sites	Brownlow Point	X			Outside project area
	Cape Simpson	X			Outside project area
	Demarcation Bay	X			Outside project area
	Kogru	X			Outside project area
	Lonely	X			Outside project area
	Oliktok LRRS		X		Outside project area
	Peard Bay	X			Outside project area
	Point Barrow LRRS		X		Outside project area
	Point Lay	X			Outside project area
	Pt. McIntyre (ND)		X		Outside project area
Oil/Gas Development					
Pt. Thomson	Far West pad				No longer proposed for development
	Sourdough	X			No proposed exploration or development plans
	Yukon Gold	X			No proposed exploration or development plans
	Kavik	X			No proposed exploration or development plans
	Kemik	X			No proposed exploration or development plans
	Sandpiper- offshore	X			No proposed exploration or development plans
	Hemi Springs	X			No proposed exploration or development plans
	Kalubik - offshore	X			No proposed exploration or development plans
	Thetis Island	X			No proposed exploration or development plans
Alpine Complex	Kuukpik	X			No proposed exploration or development plans
	Ugnu	X			No proposed exploration or development plans
	Gubik	X			No nexus
	East Karupa (gas field near E. Umiat)	X			No proposed exploration or development plans
	E. Umiat	X			No proposed exploration or development plans
NPR-A	Fish Creek	X			No proposed exploration or development plans
	Meade	X			No proposed exploration or development plans

Category		Past	Present	Future	Rationale
	Simpson	X			No proposed exploration or development plans
	Square Lake	X			No proposed exploration or development plans
	Wolf Creek	X			No proposed exploration or development plans
	Umiat	X			No proposed exploration or development plans
Western Group	Sikulik (gas field near Barrow)	X			Outside ROI
	Burger - offhsore	X		X	Outside ROI
	Klondike - offshore	X		X	Outside ROI

Sources: Exxon 2009a; TAPS FEIS; NE NPR-A EIS, 2008; PT PDEIS 2003; TAPS FEIS [OCS EIS]; OCS lease sale
Notes:
ANW Refuge = Arctic National Wildlife Refuge
DEW = Distant Early Warning
GMT = Greater Mooses Tooth
NPR-A = National Petroleum Reserve Alaska
SRRS = Short-range Radar Station
TAPS = Trans Alaska Pipeline System

6.7 PHYSICAL ENVIRONMENT

6.7.1 Meteorology and Air Quality

6.7.1.1 Region of Influence

The ROI for meteorology and air quality extends from the U.S.-Canada border to Barrow across the North Slope of Alaska. This area includes the Prudhoe Bay/Kuparuk River Unit oil and gas industrial complex, the rural communities of Kaktovik and Nuiqsut, and those resources that move in and out of the Refuge. The Project is located more than 80 kilometers to the east of the main Prudhoe Bay/Kuparuk River Unit complex. The nearest oil and gas production facility to the Project is the remote Badami Development Project, located more than 30 kilometers to the west of Point Thomson. The nearest rural community to the Project is Kaktovik, located more than 80 kilometers to the east on Barter Island off the coast of the Refuge. Nuiqsut is the next-closest rural community, located near the Alpine and Kuparuk River Unit developments more than 150 kilometers to the west of the Project.

6.7.1.2 Summary of Direct and Indirect Effects

Meteorology

As discussed in Section 4.1.1.1, local structures, such as buildings that will be constructed for the Project may interrupt local wind-flow patterns. Ambient wind conditions may be affected by structures that create a wake, where wind is forced downward and becomes entrapped on the leeward sides of buildings. Exhaust from Project equipment will cause updrafts that will affect local wind conditions. Local temperatures may be affected slightly from heat generated by the Project buildings and by equipment, such as turbines and heaters. These localized effects to meteorology will not persist outside of the Project area and will not have a measurable effect on a nearby resource.

The indirect effects on meteorology that may be caused by the Project include a possible effect on climate change from the contribution of greenhouse gases (GHG) emitted by equipment associated with the Project. The effects to climate and meteorology from GHG emissions from the Project are negligible, because the emissions would be a negligible component of GHG emissions emitted worldwide.

Air Quality

As discussed in Section 4.1.1.2, the direct effects to air quality that may result from the Project include pollutant emissions that result from combustion of fossil fuels in equipment associated with the drilling, construction, and operation of the Project. Other direct effects include a reduction in visibility associated with fugitive dust from mobile equipment on gravel roadways and pads. Indirect effects to air quality from the Project likely will not include acidification of coastal areas, because of very low sulfur in the fuels that will be combusted. Arctic haze is another minor indirect effect to air quality that may result from the activities associated with the Project. On-going ambient air quality monitoring in the Project area will form the basis for air quality modeling to support a permit application to the Alaska Department of Environmental Conservation (ADEC). A more detailed description of the direct and indirect effects to air quality for the Project is provided in Section 4.1.1.

6.7.1.3 Cumulative Effects on Meteorology and Air Quality

Past and present effects on meteorology and air quality from actions in the ROI result primarily from pollutant emissions emitted from oil and gas operations in the Prudhoe Bay/Kuparuk River Unit industrial complex and result from the combustion of fossil fuels in stationary equipment at oil production facilities. Fossil-fuel-fired equipment includes drilling rigs, power generation turbines, back-up emergency generators, and production and drill site heaters. Mobile equipment includes construction equipment such as graders; front-end loaders; haul trucks; equipment associated with aircraft flights; equipment associated with marine vessels; and vehicular traffic, such as passenger vehicles and light-duty and heavy-duty trucks. Fugitive dust emissions occur from road use and construction activities. Fugitive dust emissions are limited to the summer months because the ground is consistently snow- and ice- covered during winter, which reduces fugitive dust emissions. Fugitive volatile organic compound emissions may result from leaking oil and gas pipeline equipment such as flanges, valves, and pumps. The rural communities of Kaktovik and Nuiqsut contribute air pollutant emissions from the combustion of petroleum products in diesel-fired generator engines, heaters, and mobile vehicles. A list of the past and present actions in the ROI that are considered in this analysis is provided in Table 6-2.

The potential cumulative effects from RFFAs are difficult to anticipate because of the limited development in the area of the Project since the development of existing oil and gas production on the North Slope, and because no new substantial oil and gas deposits have been identified in the ROI. It is reasonable to assume that not all available leases will be purchased, not all leases purchased will be explored, and that most exploration will not lead to development. Future development in the air quality ROI is expected to occur within the already developed Prudhoe Bay/Kuparuk River/Alpine Unit industrial complex or to the west in the National

Petroleum Reserve-Alaska (NPR-A). If occurring, this development will be outside a 10-kilometer radius of the Project area. Other development that has strong possibility of occurring in the future in the ROI may include a gas pipeline that has been proposed to deliver gas from the North Slope to markets in North America. If developed, a major component of the project is a gas treatment plant that will be located at Prudhoe Bay more than 75 kilometers to the west of Point Thomson, although some further development at Point Thomson would be expected, to provide gas to the gas treatment plant and sales pipeline. Also, Shell has proposed to conduct an exploration drilling program in the Beaufort Sea Outer Continental Shelf. The proposed Shell drilling activity will likely be located more than 10 kilometers from the Project area. A list of the RFFAs considered in this analysis is provided in Table 6-2.

The effect on air quality from past actions that are no longer active in the ROI is not measurable and will have no cumulative effect on resources in the ROI. Past actions do not normally continue to produce air emissions after the actions are discontinued. Any air emissions from past actions are dispersed over time such that air quality will improve after these projects are ended. Air emissions from present actions and RFFAs in the ROI could accumulate in the atmosphere over time, increasing the localized concentrations of air pollutants. These air pollutants can potentially be chemically reactive and can have a synergistic effect. Synergism occurs when the damage caused by two or more pollutants, either to human health or welfare, is greater than the effect or damage caused by each individual pollutant acting alone.

An examination of the modeled air pollutant effects for present and RFFAs in the ROI provides a good comparison for determining the cumulative effects that may occur for the Project. In general, these modeling results show the effect of the Project by itself, and show the cumulative effect of the Project along with other existing and proposed air pollution sources within the affected environment. Modeling results for other projects in the ROI of the same scale in size as the Project provide a basis for describing the expected cumulative effects of the Project.

Air quality models such as the U.S. Environmental Protection Agency (EPA)-approved AERMOD model used for the Liberty Development Project (Liberty) use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Meteorological data and information regarding emission rates for equipment are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions in the atmosphere.

Sufficient information for the long-term Project emission unit inventory is not available at this time to complete an ambient air modeling exercise. However, data have been collected for sources in the ROI that show that facilities of a comparable size that emit pollutants at the levels expected from the Project and are located at a distance greater than 10 kilometers apart would have no cumulative effect to air quality. For example, air quality modeling completed by BP Exploration (Alaska) (BPXA) for Liberty shows that the highest ambient concentrations of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particles of 10 micrometers or less (PM_{10}) are within the applicable Alaska Ambient Air Quality Standards (AAAQS) and Prevention of Significant Deterioration (PSD) increment limits and occur within 200 meters of the facility boundary. The modeling for Liberty demonstrates that the concentrations are considerably reduced at distances greater than 1 kilometer. At distances greater than 10 kilometers, the emissions from Liberty are expected to have little effect on the surrounding area ([Minerals Management Service] MMS 2002). The annual pollutant emission rates for Liberty are expected to exceed the annual emissions for the Project (based on current assumptions for the Project).

Furthermore, modeling studies of proposed Outer Continental Shelf (OCS) production facilities in the Beaufort Sea prepared for OCS lease sale NEPA compliance also show that concentrations of NO_2, SO_2, and PM_{10} are within the National Ambient Air Quality Standards (NAAQS) and PSD incremental limits with the highest concentrations of NO_2, SO_2, and PM_{10} occurring within about 200 meters of the facility and considerably reduced values at distances greater than 1-kilometer (MMS 2001).

BPXA has also conducted ambient pollutant monitoring for Liberty as part of the air quality permit process. The results demonstrate that the emissions from the Prudhoe Bay complex sources have little or no measurable effect on the ambient pollutant concentrations at Liberty, located approximately 20 kilometers to the east of Prudhoe Bay. Table 3-2 and Table 3-3 (in Chapter 3) display the Liberty and Prudhoe Bay ambient air quality data collected in 2006.

6.7.1.4 Conclusions on Meteorology and Air Quality

Ambient air data show that the impact from projects in the ROI has no measurable cumulative effect on air quality with other projects outside of a 10-kilometer radius. Other ambient air data show that the impacts from the highly developed Prudhoe Bay complex have little to no effect on neighboring projects such as Liberty, located approximately 20 kilometers to the east. Because no present or reasonably foreseeable future projects are expected to occur within a 10-kilometer radius of the Project area, the Project would have no measurable cumulative effect to air quality with other actions in the ROI.

6.7.2 Geology and Geomorphology

6.7.2.1 Region of Influence

The ROI for geology and geomorphology extends 25 miles from the Staines River westward to Badami Creek and from the Beaufort Sea coast to approximately 5 miles to the south (inland). This area is generally coincident with the area occupied by the Project, which will not have a synergistic effect on geological and geomorphological characteristics outside the Project area.

6.7.2.2 Summary of Direct and Indirect Effects

Physiography and Stratigraphy

As described in Section 4.1.2.1, the potential direct effects to the physiography and stratigraphy will be caused during drilling and construction by excavations for new material sites; placement of fill for roads, pads, and an airstrip; and constructing pipelines. These activities have the potential to compress or strip the surficial organic layer, add a new surface layer (fill), and create a surficial scar on the landscape (such as the material site excavation and gravel fills). These effects are expected to be minor because they are localized and generally small-scale. Any future actions would likely be limited to expansions off the existing network of roads and pads.

Seismicity and Faults

As described in Section 4.1.2.2, there are no direct or indirect effects on seismicity and faults because the Project is not expected to induce loads large enough to affect seismicity or activate faults, and the level of seismicity is low enough that potential damage to facilities from earthquakes is unlikely.

Sand and Gravel Resources

As described in Section 4.1.2.3, the direct and indirect effects on sand and gravel resources is the resource extraction of approximately 2.65 million cubic yards (cy) of material at a new 60-acre material site. The effects also include modification of local topography, loss of surface vegetation, creation of a landscape scar, intentional ponding within the excavation, and temporary increase of dust, soil erosion, and siltation near the material site.

Paleontological Resources

As described in Section 4.1.2.4, direct effects to paleontological resources include damage during excavations for sand and gravel, burial by placement of fill, and coating by petroleum spills. These potential effects are likely to be none to minor because there are no documented important paleontological sites within the Project area, no bedrock outcrops within the ROI, the permafrost protects deeper fossil remains, and there will be a survey of cultural resources before ground disturbance that may incidently locate any fossils on the surface.

Geomorphic Processes

As described in Section 4.1.2.5, the expected effects to geomorphic processes would likely occur during construction and operation. The direct effects are expected to be the alteration of natural drainage, leading to ponding and erosion, where placement of fill can locally impede or accelerate the flow of water. The effects are likely to be minor because the climate is generally considered arid, no large streams traverse the Project area, the terrain is relatively flat (limiting water velocity), and permafrost is continuous and close to the surface.

Permafrost and Ground Temperatures

As described in Section 4.1.2.6, direct effects to permafrost and ground temperatures associated with drilling, construction, and operations will be principally from the disturbance of the surficial organics by stripping for extraction of sand and gravel and by the construction of fills for pads, roads, the airstrip, and other facilities. Unless properly protected by a sufficient thickness of fill, permafrost may, over time, either aggrade up into the fill or degrade (lowering the permafrost table) under the fill. At the toe of gravel fill structures, permafrost could degrade slightly and settle where it is ice-rich, leading to shallow ponding. These direct effects are expected to be minor, because they are likely to be localized to the footprint and margins of the affected areas.

Drilling and operation of wells induces heat into the ground and thaw bulbs can develop around the well casings, over time, leading to subsidence of ice-rich soils. These effects are likely to be moderate but can be mitigated by well design, insulation, refrigeration, and maintenance of gravel fill.

Contaminated Sites

As described in Section 4.1.2.7, the majority of the sites within the Point Thomson field area where past spills have occurred have been cleaned up. The exception to this are a staging area near Bullen Point and the North Staines River State #1 well site, both of which experience diesel fuel spills and are or will be undergoing cleanup. Thus, none of the current sites within the Point Thomson area are expected to have any future direct or indirect effects.

Disturbed Areas

As described in Section 4.1.2.8, direct and indirect effects to disturbed areas are minor and likely to be positive because of limited re-grading or covering with new fill. Further restoration of the sites may be carried out by spreading organic overburden from the new material site or similar action, if appropriate.

6.7.2.3 Cumulative Effects to Geology and Geomorphology

Past and present oil and gas exploration, development, and use of the Badami Development, and use of the Bullen Point Short-range Radar Station (SRRS) military site could have affected, or could be affected by the geologic and geomorphic environment. Reasonably foreseeable future human actions include continued exploration and development of the oil and gas resources within the area, including re-start of Badami operations, offshore exploration, such as Sivulliq, and further development of Point Thomson (including expanded gas cycling or gas sales) that could result in additional onshore pipeline and processing facilities.

The activities that could contribute to cumulative effects in the ROI for geology and geomorphology, and are therefore considered in this analysis, include the construction of material sites near Badami and Point Thomson; seismic and construction surveys; construction of gravel roads, gravel pads, and gravel airstrips; and spills. The primary potential effects to the geologic and geomorphic environment include effects on physiography and stratigraphy, an increase in overall sand and gravel resource use, combined effects on paleontological resources, effects on permafrost, effects on geomorphic processes, and a potential increase in the number of contaminated sites in the area if not appropriately remediated.

Physiography and Stratigraphy

By design, the Project could ultimately remove a large percentage of total economically recoverable petroleum hydrocarbon resources available within the area of known reserves. The Project has a limited areal footprint that is very small, roughly 1 percent of the toal existing oil field developments on the North Slope (National Research Council [NRC] 2003). Taken as a whole, the geology and character of the wider landscape will not be affected beyond the margins of constructed facilities, and the Project will therefore have no cumulative effect on these resources. The land is fairly flat, so there is no apparent threat to slope stability. The configuration of the coastline and the permafrost regime may not be affected except for minor localized changes at facility margins where the ground surface has been disturbed and drainage impeded. These local effects may be magnified to a limited extent by the current warming trend of the climate; however, cumulative effects could be expected to be minor.

Seismicity and Faults

On the basis of the analysis in Section 4.1.2.2, it is evident that the expected earthquake shaking, even using relatively conservative 2,475-year return period peak ground acceleration (PGA) values, results in only light potential damage. The presence of continuous permafrost and seasonally frozen ground make liquefaction highly unlikely. The landscape is so flat that slope stability is not an issue. The development is not on a scale that could trigger seismic events. Therefore, there are no expected cumulative effects associated with seismicity and faults in the Project area.

Sand and Gravel Resources

Over the past several decades, developments on the North Slope ranging from the Colville River to the Canning River have required the extraction of hundreds of millions of cy of sand and gravel (primarily gravel), with these extraction areas covering more than 6,400 acres (NRC 2003). The Project will require the development of a new 60-acre material site and extraction of approximately 2.65 million cy of gravel. Taken as a whole, sand and gravel resources are abundant on the North Slope and within the ROI of the Project area.

The Project material site is centrally located to the Project and, by volume, negligible in comparison to what is locally available, because sand and gravel underlies the entire ROI. The proposed development will not deplete these resources. RFFAs within or near the Project area could likely consist of more oil and gas development projects with similar sand and gravel needs. Hence, cumulative effects are expected to be minor.

Paleontological Resources

Within the ROI there are no documented important paleontological sites and the only known fossils are limited to plants and animal remains from the Gubik Formation, a Quaternary deposit of unconsolidated sediments. The cumulative effects to paleontological resources are likely to be none to minor, considering the small scale of the Project relative to other developments on the North Slope and to the vast areal extent of the Gubik Formation. The current procedures for cultural resource survey and inventory, before exploration and development, may identify fossil remains of value and thereby minimize the potential for future effects to occur. In addition, if remains are encountered over time, then they can be reported and preserved, if deemed to be of high-enough value. The exposure of paleontological resources during development activities may be regarded as revealing the resource rather than as negatively affecting the resource.

Permafrost and Ground Temperatures

No cumulative effects to permafrost are expected outside the wider margins of the new facilities. The permafrost on Alaska's North Slope is relatively cold (less than -20 degrees Fahrenheit [°F] (Brown 1997), continuous, up to 2,000 feet thick, and typically encountered within a couple feet of the ground surface (Brown 1997). The active layer thickness (depth of annual thaw and frost penetration) is generally less than 1.5 feet although may extend to three feet in depth. The permafrost in the Point Thomson region is much less vulnerable to thawing compared to areas south of the Brooks Range, where temperatures are several degrees warmer. Ground temperatures in soils more than a few yards beyond the toe of gravel fill structures, or from piles supporting pipelines, are not expected to be affected. General climate warming may have an indirect effect by increasing the average temperature of the soils, melting ground ice, releasing melt-water, increasing the thickness of the active layer and lowering the permafrost table. The extent of these indirect effects depends on many factors such as the magnitude of the warming in the coming years, the thermal regime of the permafrost, and the character and thermal conductivity of the geologic materials.

Geomorphic Processes

The cumulative effects on geomorphic processes could be minor and likely limited to relatively small alterations in surface drainage because of blockage by gravel fill, ponding, and thawing of near-surface ground ice. Slopes, streams, or waterbodies are not likely to be affected. Because construction techniques in this region have evolved over the decades, construction and maintenance activities are carried out in a way that the vegetative cover is protected and positive drainage is generally maintained. These techniques preserve the tundra, the underlying permafrost, and natural drainage patterns. While the geomorphic processes are affected at localized areas of excavation and fill, these areas are very limited and relatively small compared to the total area of the ROI, Arctic Coastal Plain (ACP), and the North Slope.

Contaminated Sites

The majority of the sites within the Point Thomson field area where past spills have occurred have been cleaned up. The exception to this are a staging area near Bullen Point and the North Staines River State #1 well site, both of which experience diesel fuel spills and are or will be undergoing cleanup. Thus, none of the current sites within the Point Thomson area are expected to have any contribution to cumulative effects.

Disturbed Areas

Cumulative effects to disturbed areas from planned and permitted removal of fill are anticipated to be minor and localized.

6.7.2.4 Conclusions on Geology and Geomorphology

In conclusion, the potential cumulative effects to geologic and geomorphic resources are expected to range from none to minor. The most notable potential cumulative effects to these resources are the effects of sand and gravel extraction; however, these effects are considered to me minor in the context of the region due to the localized nature of the activity. Cumulative effects to permafrost may also occur, but could be minor relative to the overall factors contributing to increasing ground temperatures in the Arctic.

6.7.3 Freshwater Resources and Hydrology

6.7.3.1 Region of Influence

The Project has the potential to affect freshwater resources and hydrology in the area along the coast between the Prudhoe Bay and the Staines River and contribute to cumulative effects in conjunction with other development and activities that may occur in the reasonably foreseeable future. The freshwater resources and hydrology of this area are described in Chapter 3 of this report, and the potential types of effects that could be caused by the Project are described in Chapter 4.

6.7.3.2 Summary of Direct and Indirect Effects

As discussed in Section 4.1.3, elements of the Project that could affect fresh water resources and hydrology include gravel structures (road, pads, airstrip), pipelines, material site development, ice roads, water withdrawal, permitted discharges, and spills. Based on engineering, administrative, and regulatory controls, including proposed mitigation, effects to fresh water resources and hydrology (e.g., drainage patterns, water quality, erosion, sedimentation, and thermokarsting) are expected to be minor. In the event of a large spill, effects may be determined by the type of material spilled, size, location, duration and season of release, the receiving environment, and the effectiveness of response.

6.7.3.3 Cumulative Effects on Freshwater Resources and Hydrology

Past and present oil and gas exploration and development at Badami, and use of the Bullen Point SRRS military site could have affected, and/or could be affecting, the freshwater resources and hydrology of this area. The activities that could have affected freshwater resources include: the construction of the material sites near Badami and Point Thomson; seismic and construction surveys; construction of ice roads, gravel roads, gravel pads, and gravel airstrips; water withdrawal; permitted discharges (such as sanitary waste, and stormwater runoff); and spills. The primary potential effects to freshwater resources and hydrology resulting from these activities include: an increase in erosion, sediment transport and/or sedimentation; a reduction in surface water quality as a result of turbidity and chemical input from spills; a disruption of existing drainage patterns; and a reduction in the amount of water available and possibly oxygen levels in lakes used as water supplies. While large-scale effects from these past activities are unlikely, localized areas such as in the vicinity of the old exploration pads or the Bullen Point SRRS may exhibit changes in surface hydrology or freshwater quality that have persisted. For the most part, however, it is anticipated that the effects are minor and short-lived.

Reasonably foreseeable future human actions include continued exploration and development of the oil and gas resources within the area, including re-start of Badami operations, development of gas sales at Point Thomson; exploration activities, such as Sivulliq, that could require freshwater for ice roads and exploration and development of onshore oil and gas resources. The activities that could effect freshwater resources include seismic and construction surveys; construction of ice roads, pipelines, gravel roads, gravel pads and gravel airstrips; water withdrawal; permitted discharges; spills; and decommissioning and removal of facilities. Decommissioning and removal of facilities includes plugging and abandoning wells, removal of production equipment, dismantling of facilities, decommissioning pipelines, site restoration and re-vegetation, and phasing out environmental monitoring. The primary potential impacts to freshwater resources and hydrology resulting from these activities include an increase in erosion, sediment transport, and/or sedimentation; a reduction in surface water quality as a result of turbidity and chemical input from spills; a disruption of existing drainage patterns; a reduction in the amount of water available in lakes and rivers used as water supplies; and a reduction in the available oxygen in lakes used as water supplies.

On the basis of the evaluation of potential effects associated with the Project, in conjunction with the possible effects from past, present, and RFFAs and naturally occurring events, cumulative effects to freshwater resources and hydrology of the Project area could occur; however, effects could be expected to be minor. These effects could include increases in erosion, sediment transport, and sedimentation; a reduction in surface water quality; a disruption of existing drainage patterns; a reduction in the amount of water available in lakes and rivers used as water supplies; and a reduction in the available oxygen in lakes used as winter water supplies. However, it is likely that the magnitude of the cumulative effects could be minor and that in most cases they could be localized and temporary.

6.7.3.4 Conclusions on Freshwater Resources and Hydrology

Direct and indirect effects on hydrology and freshwater resources in the ROI from the Project are anticipated to be minor, effects from past and present activities in the vicinity are believed to be none to minor in the Project ROI, and effects from RFFAs in the ROI are anticipated to be none to minor. Hence, the cumulative effects within the Project ROI are also expected to range from none to minor.

6.7.4 Physical Oceanography and Coastal Water Resources

6.7.4.1 Region of Influence

The ROI for effects on the physical marine environment and coastal erosion associated with the Project is generally limited to a localized area within Lion Bay, with the exception of large oil spills. The ROI for large oil spills is dictated by the location of the spill as well as the nature of the wind, waves, and currents occurring during and after the spill and could extend several square miles from the spill site.

Erosion effects associated with the development of coastal structures along the shoreline of the Project are estimated to be limited to within 5-10 times the length of the bulkhead (i.e., extending out from the shoreline) on either side of the bulkhead. However, the proposed bulkhead itself is located above Mean Higher High Water (MHHW), and should not contribute to coastal erosion.

Currents, waves, ice, sediment transport, and water quality effects associated with the development of bulkheads and other coastal structures along the shoreline of the Project area are limited to areas immediately adjacent to the proposed structures. Turbidity generated by suspended sediments could normally persist over relatively long periods and over long distances, but, because the currents within the bay are slow, their persistence over spatial and temporal extents becomes more limited.

6.7.4.2 Summary of Direct and Indirect Effects

As discussed in Section 4.1.4, no direct or indirect effects would be expected on physical oceanographic conditions or coastal erosion during the drilling phase of the Project. A majority of the activities associated with the Project would be located onshore during this phase, and the construction of coastal facilities and other activities that could affect the shoreline would occur primarily during and after the construction phase.

Physical Oceanography

A majority of the potential direct Project effects on marine water quality are expected to occur during the construction phase and may include screeding or dredging, pile driving, surface water runoff, and accidental discharge of hydrocarbons into the marine waters. Temporary increases in turbidity and suspended sediments associated with sediment dredging or screeding during installation of mooring dolphin, and ramp structures could be expected as discussed in Chapter 4. This would be expected to be a short-term effect during construction of the facilities and would generally be mitigated by timing construction during the winter ice-covered season when free water depth and currents are low and turbidity effects would be localized, although some summer dredging may occur following the first year of construction.

Dredging and/or screeding are likely to result in a minor change in bathymetry which in turn will have a minor affect on water circulation and increased waves and could locally enhance the development of ice ride-up and pile-up. If this occurs, it could result in increased erosion locally over the long-term. This may be mitigated by placement of additional shore erosion protection in these areas. If the material removed by dredging or screeding is sufficiently large-grained, using it to nourish the beach directly where higher waves might be expected to effect the shore could be useful.

Following construction, use of the grounded barges for offloading modules will no longer be required. Hence, suspended sediments resulting from annual maintenance screeding of the bottom sediments will end and the associated effects will also end.

An increase in the level of vessel activity in the vicinity of the Central Pad is anticipated throughout the duration of the Project. This would, in turn, increase turbulence from boat wakes, prop wash, and waves reflected off of the sheetpile. This activity is likely to increase the level of turbidity in the local area for a short period. Long-term turbidity increases are not expected.

Proper mitigation and incorporation of best management practices would likely decrease the chance and scale of any small spills and storm water runoff. In addition, the presence of a facility that allows prompt response to oils spills far outweighs the direct and indirect effects of the facility itself on the marine environment.

Overall, while project effects on physical oceanographic parameters such as increased waves and turbidity would be possible, these direct effects are expected to be minor.

Another concern associated with oil and gas development on physical oceanography is oil spills. Although considered unlikely, small spills may reach marine waters from the work pads via the down-sloping ramps or spills that occur on the coast itself during vessel-related activities. As described in Chapter 4, relatively small spills are common at North Slope facilities and the probability of a spill less than 100 gallons is high. The probability of spills from vehicle and equipment operations and maintenance type spills are rated medium (Bureau of Land Management [BLM] 2004). The probability of a very large spill, greater than 1,000 gallons, at the Project is low for on the basis of the historically low rate of occurrence of very large spills on the North Slope; and based on the location of the operations at the Central Pad, the probability of such a spill at the Project reaching marine waters is even lower. Statistically; however, there is potential for a large oil spill to occur somewhere in the ROI (either onshore or offshore) over the proposed study time frame.

The direct and indirect effects of oil spills on physical oceanography are related to water quality. Spills directly to coastal areas as well as upland spills to streams and rivers may effect the nearshore marine environment. A large crude or refined oil spill (greater than or equal to 500 barrels [bbls] from a pipeline, or 900 bbls from a facility) would affect water quality by increasing the concentration of petroleum hydrocarbons in the water column. However, the chance of a large spill occurring is considered low (MMS 2002a). The hydrocarbon concentration could exceed the 1.5 parts per million (ppm) acute-toxic criteria for a day in an area of approximately 0.77 square miles. The 0.015-ppm chronic criterion also could be exceeded for 10 or more days in an area of approximately 5 to 17 square miles. Small spills could exceed the acute-toxic level (1.5 ppm) for less than a day and chronic criteria (0.015 ppm) could be exceeded for less than a month in an area of less than 40 square miles (MMS 2008).

While only a few small spills have occurred in Beaufort Sea marine waters to date, mechanical recovery – the ADEC preferred method to respond to oil spills – generally accomplishes incomplete removal of spilled oil leaving some oil in the environment. Mechanical recovery is especially problematic in broken ice. Potential effects because of large spills to the marine environment are primarily associated with water quality effects and the resulting indirect effects to wildlife and associated hunting, subsistence, and tourism activities. These effects are covered separately in sections of this report related to the biological environment.

Chapter 5 presents the oil spill prevention mitigation measures developed for this Project. Wherever practical, Exxon Mobil Corporation (hereinafter ExxonMobil) intends to reduce the potential for spills and leaks with a spill prevention program and to mitigate the effects of spills by maintaining adequate trained oil spill response personnel and equipment.

Coastal Erosion

The dominant ice-rich permafrost soils located along the coastline of the Project area are exposed to winds, rain, and the wave environment and hence experience melting and subsequent erosion due to natural causes. The proposed development for the Project, including the construction of the barge offloading system on the north shoreline, and the Emergency Response Boat Launch and associated gangway and floating docks along the east-facing coastline of the Central Pad, could increase the erosion potential on either side of these structures. The potentially increased erosion rates are considered temporary and upon removal of the barges used during the construction phase, erosion rates would be expected to return to conditions similar to that of nearby, undeveloped coastlines.

In addition to a sheetpile bulkhead near the shoreline, the barge offloading system would employ three oceangoing barges, grounded and moored end-to-end, and extending approximately 1,200 feet out from the shoreline. The effects associated with erosion on the downdrift side are expected to be minor because the barges are to remain in place for only a couple weeks during each of the construction seasons. The bulkheads associated with the barge offloading system, located above MHHW, will not protrude from the shoreline enough to cause this type of direct erosion effect.

Vertical sheetpile bulkheads located above MHHW would be used for the barge offloading system. These bulkheads would act to retain the natural soils and fill material behind them and hence act to reduce beach erosion over the natural beach face at the site of the bulkhead. Over time, a protrusion may result at the site of the bulkheads as the natural beach on either side is left to erode naturally at a faster rate. Eventually, the effects of the protruding structure along the shoreline may cause a disruption of littoral transport and resulting sediment deposition on the updrift side and erosion on the downdrift side of the bulkhead. With proper monitoring and placement of erosion protection as required, these effects are expected to be minor. Potential erosion could be mitigated using nourishment from the screeding/dredging operation or using gravel or gravel-filled bags.

An Emergency Boat Launch and associated gangway ramp and floating dock facility is planned for the east side of the Central Pad to accommodate any need for emergency, spill response, and/or training. This facility has a small potential for inducing erosion on its flanks. However, because of its short length and protected location, any additional erosion should be minimal. Erosion could be mitigated using gravel or gravel-filled bags or beach nourishment from the screeding/dredging operation at the two bulkheads. While it might be possible that such a ramp might enhance ice run-up or pile-up, this would have a low likelihood of occurring due to the protected coastal location, and this could be considered and mitigated in the facility and operation design.

An increase in the level of vessel activity in the vicinity of the barge offloading system and the boat launch ramp at the Central Pad is anticipated throughout the duration of the Project. This would, in turn, increase turbulence from boat wakes and prop wash. However, there is a low probability that the level of wave activity resulting from the Project activities would contribute to shore erosion, and the potential effect would be minor.

While permanent effects without mitigation, such as erosion protection, are generally limited to within 1,500 feet of any coastal structure, it is unlikely that the effects would cause long-term or large-scale effects. The overall effects of the Project on coastal erosion is expected to be short-term and limited to the area directly adjacent to the structures. Because mitigation measures such as erosion protection are planned, the resulting effects associated with coastal erosion are expected to be minor.

6.7.4.3 Cumulative Effects on Physical Oceanography and Coastal Erosion

Section 6.5 provides a summary of important past and present developments and other external actions in the Project area. Section 6.6 describes the RFFAs within the Project area. These actions are listed in Table 6-2 and are considered in the cumulative effects analysis.

Past and present oil and gas exploration projects and military developments on the North Slope have modified the physical marine environment, and in some cases contributed to coastal erosion. A partial list of projects with coastal structures includes the West Dock and Endicott causeways (and its associated production islands), and the dock at Badami, as well as fills at various offshore islands such as Endicott, Northstar, Ooogaruk, and Seal. These have a direct and moderate effect on the bathymetry and water circulation as well as increased coastal erosion in localized areas.

The re-start of Badami operations, support of drilling the Liberty Project, and/or development for gas sales at Point Thomson could have effects on the physical marine environment and coastal erosion if the developments include construction of additional docks or other coastal structures and increased barge/vessel traffic. However, at this time, such effects from these activities are not considered likely.

In addition to the past, present, and RFFA developments that include coastal structures, other nearshore activities that may contribute to the cumulative effects in the region include oil and gas exploration activities, fuel transfers by barge, recreation/tourism, hunting, subsistence, transportation, and climate change. In general, exploration activities in the Eastern Beaufort Sea and Point Thomson areas (past, present, and RFFAs) have minimal effects on the physical oceanographic environment. However, there has been a major increase in vessel traffic during the open water season, primarily associated with oil and gas transportation activities. Recreation/tourism, hunting, subsistence, and transportation activities have in the past and are expected to continue to occur in the coastal areas of the region. However, these activities are considered to be minor in terms of the cumulative effects of the physical marine environment.

The effects associated with the past, present, and RFFA oil and gas and other coastal developments have in the past and are expected to include temporary increased suspended sediments and turbidity during construction of coastal facilities and an ongoing increase in barge/vessel traffic and associated erosion, turbidity, spills, and runoff effects.

In the past, the man-made and fill-enhanced islands, causeways, and docks have created shorelines that have been protected using sacrificial gravel and gravel-filled bags. Toe erosion in front of vertical sheetpile structures has also been protected from erosion using various techniques.

Unless future development includes 1) construction of docks or causeways in the nearshore or river deltas, nearshore fills, gravel islands, planned water flood discharges, or 2) if substantial dredging becomes necessary, the direct effects of RFFAs on the physical oceanography could be none to minor. Permanent cumulative effects associated with coastal erosion could likely be limited to within 1,500 feet of any coastal structure without mitigation; it could be unlikely to cause long-term or large-scale effects to adjacent areas. In addition, because the coastal structures of past developments are relatively far apart and were used during different periods of time, a remaining effect from past external actions on coastal erosion is minor. In most instances, where erosion caused by man-made structures has occurred, the adjacent shorelines were armored. The result is that the shorelines near the structures were less susceptible to erosion than the natural beach and therefore likely eroded at a slower rate.

Storms, ice pile-up, climate change and associated reduction in ice cover and resulting increase in wave action could potentially cause future effects to coastal erosion and marine water quality. Ice run-up and pile-up might be affected by additional coastal facilities, but the effect could more likely be associated with ice damage to man-made facilities or its effect on development activities, rather than the ocean environment.

Should climate trends continue, longer ice-free fetches could result in increased wave activity and permafrost is expected to experience increased melting and erosion because of exposure to waves. These effects are expected to be consistent along the entire coastline of the North Slope, with more effects experienced along shorelines that are not protected by barrier islands or erosion protection structures.

Another contributing factor to localized shoreline erosion may be the potential future major increase in vessel traffic as ice retreats and northern trade routes open up. Recent increase in activity by U.S. Coast Guard (USCG) vessels and tourist vessels has been evident. Although temporary suspended sediments may be created by vessel traffic, the primary effect of increased vessel transportation is on coastal erosion. Because of their propeller wash and boat wakes, vessels could cause increased erosion in areas that have not been armored.

Coastal development activities could increase coastal erosion if mitigation were not implemented. However, with armor protection included in coastal structure planning, each added or expanded facility cumulatively contributes to reducing erosion, in comparison to the natural undeveloped shoreline.

Fuel transfer by barge is conducted at Badami and other developments not connected by road. In addition, fuel is delivered by private barge carriers to most North Slope coastal communities including the nearest community of Kaktovik, located east of the Project. Fuel delivery by barge carries the risk of a potential oil spill to marine waters.

Other small spills may reach marine waters from the work pads via the downsloping ramps or spills that occur on the coast itself during vessel-related activities. As described previously, large spills have a potential to occur and reach marine waters; although the probability is low. Because oil spill prevention and mitigation measures as well as spill response training are strictly followed by ExxonMobil; the Project may mitigate the severity of spill effects.

Cumulative effects to water quality from a historically small release of petroleum hydrocarbons during oil spills and contamination from hazardous materials, while they may occur, are expected to be localized, limited in extent and persistence, and have minor cumulative effect to the environment. Such effects are not expected to be cumulative (MMS 2000a).

On the basis of the analysis of potential effects associated with the Project facilities, in conjunction with effects from past, present and RFFAs and naturally occurring events, it has been determined that some cumulative effects on physical oceanography and coastal erosion could occur. However, cumulative effects could be minor, on the basis of the assumptions and points presented below.

- Facilities would be built during the winter and would include mitigation measures (i.e., erosion protection and winter pile-driving) and the elements of the docking facility located in marine waters (piling) would be minimally intrusive. Further, the barges utilized for the barge offloading system would only be grounded in place temporarily, for about two weeks for each of the three construction years; the potential effect of the Project on local beach erosion is expected to be a very localized short-term minor effect. It is assumed that any other foreseeable oil and gas development projects would be constructed similarly to minimize effects to coastal erosion.
- Currents within the bay are small and therefore changes in ocean circulation associated with the Project facilities could likewise be minor.
- Turbidity/suspended sediment effects associated with the pile driving, screeding, and dredging, and construction of the boat ramp could be expected to be short-term and localized, and therefore minor.
- Over the life of the Project, increased coastal erosion that may result because of the Project could likely be a localized short-term effect, compared to long-term erosion that is assumed to result from climate change and resulting ice cover reduction, permafrost melting, increased wave activity, and increase in vessel wakes.
- At other locations along the Beaufort Sea coast between Barrow and Kaktovik, the physical oceanography and coastal erosion associated with past and future development would be expected to be affected similarly such that the effects are limited to the areas adjacent to each structure.
- Future developments in the immediate area (i.e., less than few miles) would not require an additional barge offloading structure. If additional pads were to be constructed within the vicinity of the Project, it is assumed that the barge offloading structure constructed at the Central Pad would service the other facilities by connecting them with upland gravel and/or ice roads. If this is the case, the effect of one coastal structure on coastal erosion would be limited to the localized area and could have a minor contribution to cumulative effect.
- The level of nearshore or shoreline activities would be limited and similar to existing/proposed development.
- Additionally, it is assumed that regular marine transport of supplies, product, or waste from other projects would occur in the reasonably foreseeable future, but and resulting effects associated with prop wash turbidity would be considered to be minor. Therefore, turbidity effects because of multiple projects in the area would minor.
- Spill prevention and mitigation measures will be used to minimize small spills and stormwater runoff from pads to ramp structures, as well as on the working surface of the ramp itself. If this is the case, then the effects from any small spills and surface runoff from pads, down ramp structures, to surface marine waters could have a minor contribution to cumulative effect.

- While the likelihood of a large oil spill is low, a large spill from the Project could have moderate adverse effects. Because of the onshore location of the Project and most other North Slope oil and gas developments, it is expected that the cumulative effect of the Project on water, when combined with other past, present, and reasonably foreseeable future projects, could be minor.

6.7.4.4 Conclusions on Physical Oceanography and Coastal Water Resources

The past and present effects of existing development facilities and activities within the region on physical oceanography and coastal erosion are generally limited to the localized area adjacent to a coastal structure. Because existing facilities are relatively far apart, and future facilities are expected to be similarly located, the effects associated with one facility could not be expected to increase the direct effects at any nearby facility. Any construction efforts associated with future developments would be separated in space and time from efforts associated solely with the Project. Hence, the potential contribution of the Project to the cumulative effect is considered none to minor because:

- The Project area is protected from the most vigorous wave activity by barrier islands, or bars, that reduce the overall level of longshore currents and the associated turbidity. Therefore, the changes in these conditions because of wave sheltering and/or reflection could be minor.
- The bulkhead facilities and armor protected shoreline areas associated with the Project serve to protect the immediate shoreline from the higher erosion rates that are expected to occur naturally.

The presence of an Emergency Launch Ramp facilitates oil spill response; and this capability outweighs the probable effects of this facility on coastal erosion and marine water quality.

6.7.5 Climate

6.7.5.1 Region of Influence

The ROI for climate change is the entire Arctic region of Alaska, including the Alaska North Slope, the Northwest Alaska coast, and the Alaska OCS Beaufort and Chukchi seas. The particular region of interest is the Alaska North Slope from Barrow to Kaktovik, and the State of Alaska and federal OCS waters of the Beaufort Sea.

6.7.5.2 Summary of Direct/Indirect Effects

The primary mechanism for potential effects of the Project on climate change would be the emission of GHGs from project equipment and vehicles. However, as discussed above in Section 3.7.5, no definitive anthropogenic factor in arctic climate change has been established. The Project - all phases: drilling, construction, and operations as discussed in Section 4.1.5 - would have no direct effect on climate change. In addition, the indirect effects to the physical, chemical, and biological environment associated with GHG emissions from the Project would be negligible. The intermittent duration of the Project drilling and the temporary nature of the three-to-four year construction period could result in a brief, temporary, and periodic effect even if any effects were measurable. The Project operation phase will employ modern fuel efficient (lower GHG emitting) turbines, and utilize waste heat recovery.

6.7.5.3 Cumulative Effects on Climate

Section 6.4 provides a summary of important past developments and actions in the development area. The State of Alaska 2005 GHG emissions estimate was 53 MMT CO_2e statewide for all sources and 15 Million Metric Tons (MMT) CO_2e for the oil and gas sector, principally from the North Slope (ADEC 2008). The North Slope oil and gas sector GHG emissions were approximately 28 percent of the state total, 0.2 percent of the nationwide total and less than 0.04 percent of the global total.

Section 6.5 also describes RFFAs that could occur in the Project area. In particular, the MMS, the BLM, and the Alaska Department of Natural Resources (ADNR) evaluated RFFAs on the North Slope and the federal OCS Beaufort Sea within the past two years (MMS 2008; BLM 2008; ADNR 2009). The MMS estimated GHG emissions from the proposed Beaufort Sea Lease Sales could be between 0.345 to 1.278 MMT CO_2e (MMS 2008). Conversely, the BLM projected emissions on the North Slope as a whole could decrease as the result of an overall downward trend in oil production and advances in emission control technologies (BLM 2008). The State of Alaska anticipated future North Slope GHG emissions to decrease due to expected declining oil and gas production. From 1977 to the end of 2006, North Slope developments produced 15.4 billion barrels (Bbbl) of oil and natural gas liquids (ADNR 2007). The ADEC projected Alaska fossil fuel industry future fugitive GHG emissions from the extraction of fossil fuel resources will decrease from 4.9 MMT CO_2e in 1990 to 2.1 MMT CO_2e in 2020 (ADEC 2008).

6.7.5.4 Conclusions on Climate

To date, no definitive anthropogenic (human induced) signal has been identified causing the Arctic warming observed during the past century (Arctic Climate Impact Assessment [ACIA] 2005). Even if a direct causative relationship is assumed between GHG emissions and Arctic climate trends, then the potential effect from GHG emissions from an individual project such as the Project is expected to be minor compared to the effect from global, nation-wide, and Alaska GHG emissions totals. Thus there is expected to be a negligible contribution from the Project on climate change trends in the Arctic, and cumulative effects are therefore anticipated to be none to minor.

6.7.6 Noise

6.7.6.1 Region of Influence

The ROI for cumulative effects from noise includes the North Slope of Alaska from Kaktovik to Barrow. The ROI covers the Project area and all anticipated support services such as flights and other transportation. This section analyzes only the potential cumulative effects on human receptors. Cumulative effects on wildlife receptors are addressed in the biological resources Section 6.8.

6.7.6.2 Summary of Direct and Indirect Effects

Key Project actions that could result in noise effects include use of drill rigs and heavy equipment during drilling and general construction, followed by maintenance and operations at the central processing facility and pads. Local air, ground, and marine transportation could also increase in support of construction and long-term operations. The most intense effects from Project related noise could occur during the drilling and construction phases. These effects could be short-term - planned to occur over three winter seasons - and primarily localized to the area within 2.5 miles of the Project, including the pipeline route. The overall effect of noise during drilling and construction could be minor. Noise generated during operations is expected to be less intense but it could persist for the life of the Project and be considered a moderate effect. Sensitive receptors (including North Slope residents and visitors) may be able to detect operational noise within 30 miles of the site under certain climatic conditions. However, additional modeling and baseline data collection will be required for further assessment of potential direct and indirect effects of Project related noise.

6.7.6.3 Cumulative Effects of Noise

Past and present actions in the ROI include military operations; oil and gas exploration, seismic investigations, and drilling; construction and operation at the Badami Development, currently approved drilling operations at Point Thomson; scientific research and surveys conducted in the area; remediation in the Project area (air and vessel traffic and noise from heavy equipment); and subsistence and commercial hunting. These actions have resulted in only minor noise-related effects on human receptors due primarily to the remoteness of the region and temporary nature of most noise events.

RFFAs that could result in noise effects within the ROI are limited to on- and offshore oil and gas exploration, development, and transportation (Table 6-2). This includes activities associated with the re-start of Badami, and Beaufort Sea offshore exploration. Associated actions and effects from noise could be nearly identical to those described for the Project in Section 4.1.6, albeit in distinct locations. These actions could individually result in incremental increases in localized noise from drilling, construction, and operations of equipment. Sensitive receptors, including residents of and visitors to the North Slope who transit the area or recreate in the Refuge, may experience noticeable changes to ambient noise levels as a result of localized and/or temporary, low to medium intensity noise. Visits to the Refuge, which occurs primarily during the summer, generally occurs within 12 miles of the East Pad at the Canning River take-out site, although some visitation may also occur closer to the East Pad. Kaktovik, the nearest community to the Project, is located approximately 60 miles to the east, although residents travel through the Project area during the summer and winter.

Transportation of workers, equipment, and supplies via aircraft, marine vessels and, to a lesser degree, terrestrial vehicles could also increase incrementally with each additional facility in areas located along travel routes. Visitors to the Refuge and residents traveling through the area could be affected to varying degrees depending on the ultimate implementation schedule of the RFFAs and associated travel routes. Changes in noise levels throughout the ROI are not expected to be noticeable over existing conditions; however, the rate of recurrence may increase.

6.7.6.4 Conclusions on Noise

The cumulative effects of noise are expected to be minor given that most actions could be localized to isolated facilities. Long-term increased activity of air, marine, and terrestrial traffic could result in intermittent, low-intensity noise. Noise attributable to the Project is not expected to be measurable when considered in the general context past, present, and RFFAs within the ROI.

6.8 BIOLOGICAL ENVIRONMENT

6.8.1 Marine Benthos

6.8.1.1 Region of Influence

The ROI for marine benthos encompasses the North Slope nearshore areas along the Beaufort Sea coast between the U.S.-Canada border and Point Barrow. In this section, the nearshore area is considered the area between the shoreline and the 10-meter isobath. This zone is considered adequate to evaluate the contribution of anticipated Project effects to potential cumulative effects on marine benthic organisms and marine benthic habitat.

6.8.1.2 Summary of Direct and Indirect Effects

As summarized in Section 4.2.1, the potential direct effects on marine benthos include habitat loss, disturbance, and mortality from the following aspects of the Project: the temporarily grounded and ballasted barges, the Emergency Response Boat Ramp gangway pilings, seafloor screeding and dredging, increased barge traffic, and accidental spills and leaks. The screeded and dredged area is estimated to be a maximum of 1.4 acres, the mooring dolphins will cover less than 0.1 acre of benthos habitat, the temporarily grounded and ballasted barges will cover approximately 2.9 acres of benthos habitat and the Emergency Response Boat Ramp gangway pilings will cover approximately 0.1 acre.

The grounded and ballasted barges will be in place for approximately two weeks, whereas the Emergency Response Boat Launch and mooring dolphins will be "life of the Project" structures. The Emergency Response Boat Launch and mooring dolphins will have very limited potential effects on benthos because of the amount of habitat affected compared with the habitat overall available to benthos.

The benthic community in this zone is dominated by motile opportunistic species that normally re-colonize annually. Therefore, the direct effects of habitat loss, mortality, and disturbance will be relatively minor because these organisms and their habitat regularly go through periods of natural disturbance, mortality, and recolonization.

The disturbance of benthic organisms may have an indirect effect on consumers (such as fish and birds) that feed on marine benthic organisms. The effects of alterations to the marine benthic community on consumers are addressed in Sections 4.2.3 (Fish), 4.2.4 (Birds), and 4.2.5 (Marine Mammals).

6.8.1.3 Cumulative Effects on Marine Benthos

There have been no previous nearshore projects in Lion Bay or in the immediate vicinity of the Project, although there were gravel pads constructed on Flaxman, Northstar, and Alaska islands for exploration drilling. Past external effects outside of Lion Bay include approximately 20 offshore gravel islands that have been used to support oil and gas exploration or production operations (ADNR 2001 in NRC 2003). In addition to the Badami Dock, two gravel causeways have also been constructed and include West Dock and the Endicott Causeway. The offshore gravel islands and pads cover approximately 155 acres of benthic habitat and the causeways cover approximately 227 acres of benthic habitat (NRC 2003). Oil and gas exploration and development have also affected small acreages of benthic habitat through buried sea pipelines, dredging, and other activities in nearshore waters of the North Slope; however, the amount of habitat affected by these activities has not been quantified.

Of the 20 offshore gravel islands that have been constructed over time, the three main developments that are currently operating are Endicott (including the Liberty expansion) and Northstar, and Ooogaruk (Table 6-2). The West Dock and Endicott gravel causeways are still present and in use.

Studies conducted on the North Slope have concluded that man-made hard substrates, such as artificial islands or causeways, may provide some benefit in the form of substrate but, generally, benthic invertebrates have been slow to colonize these habitats (NRC 2003). Permitted discharges do not appear to have adversely affected Beaufort Sea benthic communities or habitat; however, monitoring data that are required by discharge permits are not readily available in summarized form (NRC 2003). The current trend towards disposal wells, including the Project, makes such permitted discharge less of a concern. Epontic communities, those that live in or on the underside of ice, have not been well-studied; however, the general consensus is that oil and gas exploration and development have not affected these communities (NRC 2003). Epibenthic invertebrates and sessile invertebrates in the boulder patch community have not experienced any measurable effects from oil and gas development on the North Slope (NRC 2003).

Reasonably foreseeable offshore exploration activities include Stinson, and Hammerhead/Sivulliq (Table 6-2). The Hammerhead/Sivulliq exploration activities could be outside the barrier islands, which could reduce the risk to river deltas and sensitive coastal habitats (MMS 2003). These activities are likely to utilize drillships or jackup rigs, the latter which may also require some minor seafloor screeding, potentially affecting benthic organisms. Given the total amount of habitat available to benthic organisms, the low density of benthic organisms, and the relatively small area that could potentially be affected, the potential cumulative effects to benthos could be minor.

The Project drilling, construction, and operations may have a minor contribution to the overall cumulative effects on marine benthos in the nearshore Beaufort Sea. The potential cumulative effects from the Project are anticipated to be additive with respect to effects from other development activities on the North Slope; no countervailing or synergistic cumulative effects are anticipated. The limited amount of past, current, and future offshore development, combined with the resilient nature of the nearshore benthic community in the Beaufort Sea, make the overall potential cumulative effects minor, because they are likely to be short-term and localized.

Slope-wide, the main development components that may have cumulative effects on benthos include permitted discharges; dredging, seafloor screeding, and structures (i.e. causeways) that alter flow patterns; temperature; and salinity (NRC 2003). To date, there have been few documented effects on the Beaufort nearshore benthic community as a result of oil exploration and production on the North Slope (NRC 2003). The Project will not contribute to permitted discharges and will only have temporary dredging and screeding activities. In addition, the

Project will not have a causeway structure. Future projects may require some form of barge off-loading facility and seafloor screeding; however, similar to this Project, these activities could be for limited time frames and on small spatial scales.

6.8.1.4 Conclusions on Marine Benthos

The overall footprint of benthic habitat potentially affected by the Project is less than 5 acres, which constitutes only 1.3 percent of the total amount of benthic habitat that has been affected to date by North Slope oil and gas and other coastal developments. The limited amount of past, current, and future offshore development, combined with the resilient nature of the nearshore benthic community in the Beaufort Sea, make the overall potential cumulative effects minor, because they are likely to be short-term and localized. Given the total amount of habitat available to benthic organisms, the low density of benthic organisms, and the relatively small area that could potentially be affected, the potential cumulative effects to benthos are minor.

6.8.2 Vegetation and Wetlands

6.8.2.1 Region of Influence

The general geographic region of consideration for the cumulative analysis was the North Slope region of Alaska, as defined by the drainage basin north of the Brooks Range. The North Slope of Alaska is 89,000 square miles (230,000 square kilometers), gradually sloping from the crest of the Brooks Range to the Arctic Ocean. Of the three major regions of the North Slope (ACP, Arctic Foothills, and Brooks Range), the vast majority of development to date has occurred in the ACP. There is, however, increasing exploration in the Arctic Foothills. Considering the entire North Slope for the cumulative effects analyses will capture the Project's anticipated effects, as well as past and reasonably foreseeable future development's effects on vegetation and wetlands, allowing an integrated analysis of cumulative effects.

6.8.2.2 Summary of Direct and Indirect Effects

As summarized in Section 4.2, the direct effects of the Project on vegetation and wetlands include mortality because of gravel mine development, placing gravel fill for construction, and placing pipeline vertical support members (VSMs) in tundra. Direct and indirect effects also include disturbance because of ice roads and pads, spills and leaks, lake water removal, snow dumps and snow drifts, and the potential indirect effects of gravel placement (fugitive dust, thermokarst, and surface water impoundments). It is estimated that approximately 300 acres of vegetation will be lost to fill and gravel mining during the construction phase of the Project, with approximately 130 additional acres of vegetation affected by fugitive dust from operations on gravel fill. Ice roads and pads will result in temporary effects to another 480 acres of common vegetation types. Direct and indirect effects on vegetation and wetlands from the Project are anticipated to be minor to moderate.

6.8.2.3 Cumulative Effects on Vegetation and Wetlands

Past and present external actions affecting the vegetation and wetlands of the North Slope of Alaska include those developments in Table 6-2 with an onshore development component (e.g., community development, military installations, onshore oil and gas development, etc.). Oil and gas development is generally responsible for the greatest effects to vegetation and wetlands within the ACP through direct loss and disturbance by gravel fill (BLM 2004). NRC (2003) states that, excluding the Trans Alaska Pipeline System (TAPS) and Dalton Highway, more than 17,000 acres of tundra and floodplains on the North Slope have been directly covered either by placement of gravel fill or by disturbance from gravel mining associated with oil and gas development. While few detailed analyses of the indirect effects of gravel fill (e.g., surface water impoundments, thermokarsting, fugitive dust effects, etc.) have been performed for the North Slope, NRC (2003) estimated 10,500 acres of vegetation were indirectly affected by gravel roads alone. Walker et al. (1987) examined aerial photography of three heavily used areas within the Prudhoe Bay Unit both before and after development; indirectly affected vegetation comprised a greater area than directly affected vegetation. While the developments analyzed by Walker et al. (1987) are not representative of more recent activities, as technological improvements now allow smaller gravel footprints, they are still useful for documenting the potential extent of indirect effects associated with gravel fill.

Past external actions affecting the vegetation and wetlands of the Project area include the construction of more than 100 acres of gravel pads for exploration and military activities: these Bullen Point SRRS, Staines River exploration, and several other oil exploration activities.

Reasonably foreseeable future external actions with the potential to contribute effects to vegetation and wetlands include those activities presented in Table 6-2 with an onshore development component, including expansion of existing facilities and potential gas sales pipeline and associated facilities. Additionally, actions generating an increased use of area roads (e.g., tourism or sport hunting along the Dalton Highway, etc.) could potentially contribute effects to vegetation and wetlands on the North Slope, although effects associated with trampling are anticipated to be none. Any future development could affect vegetation, although the current trend of roadless development, directional drilling, and pad footprint reduction minimizes overall vegetation loss. Future community developments may also require additional fill and mortality of vegetation, as may any future military or industrial developments on the North Slope.

As described in Chapter 3, Affected Environment, the increased warming trend is anticipated to continue exerting effects on Arctic vegetation. While predicting the exact nature of these changes is tenuous at best, potential changes may include different species and species assemblages, loss of freshwater lakes, and loss of wetland habitats associated with continued permafrost thawing. The uncertainty of climate change’s effects on Arctic biota adds a degree of uncertainty to all cumulative effect analyses; NRC (2003) states that “effects of current activities could be much greater on the permafrost landscape than would be the case if the climate were relatively stable.”

Overall, cumulative effects of disturbance and mortality and loss to vegetation and wetlands on the North Slope from existing and potential developments on the North Slope are considered minor. The effects to vegetation and wetlands from the Project (drilling, construction, and operations) are anticipated to be additive with respect to effects from other development activities on the North Slope; no countervailing or synergistic cumulative effects are anticipated.

The Project is anticipated to have a minor contribution to the cumulative effects to vegetation and wetlands. The contribution could include the approximately 300 acres of tundra lost to gravel placement and gravel mining, which comprises roughly 1 percent of all permanent fill on the North Slope (based on the approximate 17,000 acres of buried or excavated vegetation documented by NRC, 2003). This small percentage is a minor adverse contribution to the cumulative effect of gravel placement on the North Slope.

Because the effects of ice roads and pads are temporary, they could not be expected to contribute to the overall cumulative effect. The indirect effects of gravel placement to Point Thomson vegetation and wetlands, including snowdrifts and snow dumps are also anticipated to have a minor contribution to the cumulative effects on vegetation.

Several recent EIS documents conclude that the overall effects to North Slope vegetation and wetlands from placement of gravel fill have been minor, with only a very small fraction of the total North Slope acreage affected (BLM 2004; BLM 2002).

6.8.2.4 Conclusions on Vegetation and Wetlands

The Project will have direct and indirect effects associated with the loss of approximately 300 acres of tundra vegetation and wetlands in the Project area from gravel fill for road and pad and excavation of the gravel mine. Ice roads and pads could have temporary effects on another 480 acres of common tundra vegetation. The overall cumulative effect of loss of tundra vegetation and wetlands in the ROI is considered minor. The contribution of the Project to the overall cumulative effect of loss of tundra vegetation is roughly 1 percent of the total for the North Slope and is considered minor.

6.8.3 Fish

6.8.3.1 Region of Influence

Marine Fish and Nearshore Habitats

Marine fish in the Beaufort Sea are capable of extensive movements, both between offshore and nearshore habitats, and east/west within the nearshore zone. Quantitative information about the extent of these movements that could be used to determine the ROI for an analysis of cumulative effects is lacking. However, marine species such as the Arctic cod are highly mobile, and diadromous fish that use the nearshore zone (e.g., Arctic cisco) are documented to travel along hundreds of miles of shoreline. Accordingly, and conservatively, the geographic area assessed for this cumulative effects analysis on marine fish habitat is the North Slope from Barrow, Alaska, and east to the Mackenzie River in Canada.

Freshwater and Diadromous Fish

After ice break-up, a number of freshwater and diadromous fish species move to feeding and rearing locations, often traveling long distances between major freshwater rivers and along the nearshore marine environment. The Colville, Mackenzie, and Sagavanirktok rivers in particular are thought or known to be important spawning and overwintering areas for species such as Arctic cisco and broad whitefish. During the open-water season, these fish disperse to smaller drainages and coastal habitats that do not provide suitable overwintering habitats. Accordingly, the geographic area assessed for this cumulative effects analysis on fish ranges from the Colville River in the west to the Mackenzie River in Canada in the east. This ROI includes the large majority of the freshwater and nearshore marine habitat that these freshwater and diadromous fish species depend on in the Project area.

6.8.3.2 Summary of Direct and Indirect Effects

Marine Fish and Nearshore Habitats

Direct effects of spills that reach the marine environment span both drilling and operations phases of the Project. The primary risk of spills that could reach the coastal marine or lagoon environment is from accidental releases during barge landing and off-loading operations. Spills could degrade or effectively eliminate habitat through direct toxicity, reductions in water quality, or changes in the types and number of plants and animals present through mortality or avoidance. Spills could have an effect on transient populations of fish that rely on the directly affected habitat and species. Such effects would be none to minor because large spills, including those that might result from barging operations, are very unlikely, and because small spills would be contained and quickly cleaned up.

The entrainment of nearshore marine fish (e.g., Arctic flounder, four-horned sculpin) during pumping of sea water associated with ice road construction would not have effects at the population level, but local effects may occur to fish that use the withdrawal areas.

During the construction and operation phases of this Project, the direct effects of barge and small boat traffic and associated infrastructure would be limited to a grounded barge off-loading structure and a boat ramp and float used for emergency spill response. A portion of the nearshore benthos from -1 to -6 feet Mean Lower Low Water (MLLW) (approximately 1.2 acres) could be dredged and screeded to accommodate larger open-ocean barges that will carry large modules. Effects of this activity on marine fish or habitat in the lagoon would be none to minor.

For the barge bridge off-loading facility, two of the three grounded barges would pose a minor barrier to fish movements for the approximate two week delivery season in July and August. Most fish in the landing areas are likely to move away in response to the noise and disturbance associated with barge arrivals. Thus, effects on fish from boat and barge landings would also expected to be minor.

Freshwater and Diadromous Fish

Large volumes of water would be required during all phases of the Project (drilling, construction, and operations), with most of this water initially coming from area lakes and previous gravel-mining-related ponds. Once the new gravel mine is flooded and is available as a permanent water source for the Project, the effect of surface water withdrawals on fish would probably be limited to various tundra ponds and lakes along the path of the proposed sea ice road from Point Thomson west to Endicott. This ice road will be used during the construction period, but is not expected to be in regular use during operations. Effects of this water withdrawal on fish would be expected to be minor, primary due to regulatory limits on withdrawals in streams and lakes thought or known to contain fish. Effects of water withdrawal on fish would be none to minor.

Potential spills could occur during any phase of the Project, but during drilling and construction any spills would likely be small and easily cleaned up. The major concern is with a large spill from barging operations during construction or from one of the pipelines during the operations phase as such a spill, although unlikely, could have a minor to moderate localized effect on freshwater and diadromous fish resources.

During the construction phase in particular, areas of tundra and local tundra ponds would be covered with gravel for new roads, pad areas, and the airstrip. Some of the ponds could support fish. In other cases, gravel placement would result in a barrier to overland flow of water during spring break-up (especially before culverts are thawed) or result in a potential for ponding of water behind gravel structures, and erosion or high flows at culverts and bridges, any of which could impede fish movements or habitat quality. Water quality effects could occur from sediment runoff and dust during construction, use, or maintenance of gravel roads, pads, or the airstrip. Either source could increase turbidity or result in in-stream sedimentation. Overall, effects would be minor.

Changes in downslope habitat quality could occur from diversion of surface flows to the gravel mine. Initially, water would be diverted from surface waters into the new gravel mine to create a new water source. On an annual, basis additional water would be diverted to make up for prior water use. Focusing diversions on the high flow period during ice break-up, and the use of an intake structure to limit direct entrainment of fish, would help to reduce these potential effects.

As discussed in Section 4.1.3, the Project proposes to use a variety of construction and maintenance methods (Best Management Practices [BMPs]) and other mitigations to reduce the effects of drilling, construction, and operations on freshwater and diadromous fish and their habitat. As a consequence, the direct and indirect effects of the Project on these fish resources would be minor in magnitude, localized in extent, and, in most cases, temporary or short-term in duration.

6.8.3.3 Cumulative Effects on Fish

Marine Fish and Nearshore Habitat

Past and present actions in the Beaufort Sea nearshore marine environment have been almost exclusively associated with oil and gas exploration and development. Major marine and shoreline facilities include the West Dock and Endicott causeways, East Dock, the Badami Dock, and Endicott (including Liberty, Eider and Sag Delta North), the Heald Point/Niakuk facility, the Oliktok Dock, and Ooogaruk and Northstar offshore developments, A number of exploratory wells have also been drilled in the nearshore zone. The total acreage of marine development affects a very small proportion of the total marine and nearshore habitat present in the geographical area of this assessment.

Past and existing actions have demonstrated that marine fish are much less vulnerable to effects from oil and gas exploration and development than freshwater fish (BLM 2008). Only a few small spills have occurred in the Beaufort Sea marine environment, and permitted discharges from facilities have been limited (BLM 2008).

Past and present effects to marine fish from sea ice road development are also expected to be localized and minor, with no effects on fish populations. The West Dock has had documented effects on fish movement and water circulation, but modifications to enhance fish and water circulation appear to have lessened these effects (BLM 2008). Any residual effects, when combined with effects from the Endicott causeway, may have resulted in minor effects on marine fish.

RFFAs include additional marine and shoreline structures associated with oil and gas exploration and development. It is difficult to predict the scope of such development, except that it will likely follow the historic pattern of being limited in relation to onshore facilities. In addition, even assuming a large coast-wide increase in marine construction and activities, the total acreage of development could still affect a very small proportion of the total marine and nearshore habitat present in the geographical area of this assessment.

The exception to this could be a large spill of petroleum products (e.g., from a tug boat or barge shipment of fuels, or a pipeline spill that entered marine waters) directly into the marine environment, or that entered the nearshore environment from an inland spill. A spill occurring during the open-water season could quickly extend over a large area because of wind and currents, potentially affecting a sizeable proportion of the marine resources along the North Slope. However, no marine spill of this magnitude has occurred on the North Slope during the last 30+ years and is therefore not considered likely.

On the basis of the analysis of likely effects of the Project with past, present, and reasonably foreseeable potential actions, cumulative effects on marine fish and nearshore habitats could occur. These effects are considered minor on marine nearshore habitat and associated fish with no population-level effects on marine fish in the geographic area. Long-term monitoring of coastal fish populations in areas with more intensive coastal and onshore oil production (e.g., Prudhoe Bay) have shown no trends in species decline that are attributed to the development to date (Fechelm et al. 2009).

The Project could contribute incrementally to the actual or potential cumulative effects on marine fish and habitats, but that contribution would be minor given the small area and limited direct and indirect effects that may result from the Project.

Freshwater and Diadromous Fish

Although remote and sparsely populated, the geographic area for this cumulative effects analysis for fish includes a number of past and present actions, the majority of which, like the Project, are related to oil and gas development and exploration (Table 6-2). Thus, the greatest potential for effects on freshwater and diadromous fish could derive from oil and gas exploration, extraction, and transport, with lesser effects possible from Alaska Native, military, or public projects.

The cumulative effects of concern are largely the same as those listed for direct and indirect Project effects: spills; effects to habitat from water withdrawals; habitat losses from development of gravel roads, pads, and airfields; effects to water quality from runoff and dust; and blockage of stream flows and fish passage from gravel and ice roads.

Because frozen conditions dominate in the geographic area, potential effects to fish from many spills are greatly reduced because spills can usually be cleaned up before the arrival of open water and return of fish from overwintering areas. A thorough review of the environmental effects of past oil spills on the North Slope concluded that the effects of spills on fish have not accumulated over time (NRC 2003). Thus, spills seen to date have not resulted in detectable effects on freshwater and diadromous fish.

Water withdrawals from rivers and tundra ponds and lakes have been a widespread part of oil and gas development activities in the assessment area, and will likely continue into the future. However, water bodies used for freshwater can be successfully refilled during the high flows at ice breakup (Streever et al. 2001; Hinzman et al. 2006) with little persistence of the effects of these withdrawals.

Past and present development of gravel roads, pads, airfields, and other structures results in the filling of tundra pond and lake habitats used by fish. Gravel fills have affected a very small percentage of the total freshwater habitat in the geographic area, and fill of the most important habitats, large rivers and lakes, has been none to minor to date.

Ice roads that cross tundra lakes or streams, and gravel roads or other structures containing culverts or bridge crossings, can impair fish movements. Because they melt each year, ice road effects on the movement of surface waters and fish are necessarily temporary, but recurring, whereas effects from culverts and bridges are long-term and, in many cases, over the life of a project. Little to no past effects to fish passage have been recorded (BLM 2004), probably in large part because of implementation of these types of BMPs.

A number of reasonably foreseeable future actions that could affect freshwater fish are likely in the geographic area (Table 6-2). Most of the currently operating oil and gas developments could continue into the future, and exploration to find undiscovered prospects could also continue. Presumably one or more of these exploration efforts could lead to new development activities with associated construction and operational effects on fish. Thus, as with effects from past and present actions, the greatest potential contributions for future effects on freshwater and diadromous fish could derive from oil and gas exploration, extraction, and transport, with lesser effects possible from Alaska Native, military, or public projects, including subsistence fishing and localized development associated with North Slope communities.

Movement of freshwater and diadromous fish may be impaired by ice roads, gravel roads, and other structures associated with future actions. As additional developments occur in the geographical area, the miles of ice and gravel road and the number of culvert/bridge stream crossings could increase, leading to an additive effect on freshwater and diadromous fish and aquatic habitat. Proper design and maintenance of culverts and bridges, and clearing of blocked stream and lake crossings during ice break-up, can mitigate many of these adverse effects in the future.

Freshwater and diadromous fish populations could continue to be subject to the additive effects of oil and gas development and Alaska Native subsistence harvest. However, because future oil and gas development is not expected to have population-level effects on fish, and because subsistence fishing could likely continue to remove only a small part of total available fish stocks, these effects are expected to be localized. The cumulative effects of subsistence are discussed further in Section 6.9.3.3.

On the basis of the analysis of likely effect of the Project with past, present, and reasonably foreseeable potential actions, cumulative effects on freshwater and diadromous fish and their habitats could occur because of freshwater withdrawals, effects of roads, pads, airstrips, ice roads, and associated structures include localized effects on water quality, fish movement, and the total habitat available. These effects are additive, but, given the total amount of habitat affected, and design and maintenance approaches that could minimize and mitigate effects, the overall cumulative effect would be minor.

The Project could contribute incrementally to the actual or potential cumulative effects on freshwater and diadromous fish and habitats, but that contribution is expected to be none to minor given the very small incremental additions that may result from the Project and the relative resilience of these fish species to the types and magnitudes of effects that result from development activities in the geographical area.

6.8.3.4 Conclusions on Fish

The Project would have direct and indirect effects on marine fish species from the grounded barge off-loading system and potential spills. Cumulative effects on marine fish and nearshore habitats could occur. The Project could add incrementally to the actual or potential cumulative effects on marine fish and habitats, but that contribution would be minor given the limited direct and indirect effects and very small area affected in comparison to available habitat in the nearshore lagoons of the Beaufort Sea.

Direct and indirect effects of the Project on freshwater and diadromous fish include loss of habitat from water withdrawals, gravel fills and gravel mine development, degradation of water quality and potential contaminant and oil spills. The overall cumulative effect of loss of habitat in the ROI could be minor. The contribution of the project to the cumulative effect would be minor due to the small area affected in comparison to available habitat on the North Slope.

6.8.4 Birds

The cumulative effects analysis for birds covers those species that occur in the Point Thomson region, except for three species (Yellow-billed Loon, Steller’s Eider, and Spectacled Eider) that are covered in Section 6.8.7, Threatened and Endangered Species. The analysis focuses on those bird species most likely to be affected by the Project and other past, present, and reasonably foreseeable future activities.

6.8.4.1 Region of Influence

The ROI for birds extends from Barrow eastward to the U.S.–Canada border. This region encompasses most of the NPR–A, all of the currently developed oilfields, the Point Thomson region, and the adjacent Refuge. The ROI extends southward to the Brooks Range foothills.

Summary of Direct and Indirect Effects

Ice roads, ice pads, associated snowdrifts, and snow dumps created during winter drilling are expected to result in minor effects due to temporary habitat loss the following summer and reduced availability of nesting sites for some bird species (passerines, shorebirds, possibly geese). Drilling noise and traffic would occur in winter and would result in minor effects on birds, because most would be absent from the Project area during winter. Bird mortality would be minor to moderate and result from potential collisions of birds with the drilling rig during spring migration under adverse weather conditions. Other potential sources of mortality for birds (particularly ptarmigans, ravens, or early arriving passerines, such as Snow Buntings) due to potential spills and leaks of oil or other contaminants on pads, roads, or adjacent snow are likely to be minor to moderate.

Winter construction activities would occur when most birds are absent and would result in minor effects on birds. Gravel placement would result in the permanent loss of bird habitats and might affect habitats by impounding water, dust fallout/thermokarst changes to roadside vegetation, and impeding movements of brood-rearing birds. Other minor to moderate adverse effects of construction might be increased mortality from collisions of birds with vehicles, structures, or communication towers; from increased predator populations; or from oil or other contaminant spills.

Minor indirect effects on birds from gravel roads and pads, such as changes to habitats from obstruction of flow (impoundments), thermokarst, and dust fallout, would likely continue during the operations phase. Potential disturbing activities that would occur regularly during operations include vehicular traffic, facility noise, and aircraft traffic. Potential mortality, as described for the construction phase, would likely result in minor effects because human numbers and activities associated with operations would decrease in the Project area compared with construction levels.

6.8.4.3 Cumulative Effects on Birds

Past and present oil and gas development activities include the established oilfields (Prudhoe Bay, Kuparuk, Endicott, Milne Point), but also the newer fields (Alpine, Alpine satellites, Oooguruk, Northstar, Badami), and exploration activity within the NPR–A and ongoing drilling operations at Point Thomson (see Table 6-2 and Sections 6.5 and 6.6). The features of these industrial developments that can affect birds are varied and include habitat alteration from ice pads/ice roads; collisions with drilling rigs; disturbance from construction activities; habitat loss, alteration, and disturbance associated with gravel roads/pads; collisions with modular buildings, communication towers, and power transmission lines, as well as with vehicles and aircraft; attraction to gas flares; disturbance from operations activities; and increased predation from mammal and bird predators attracted to industrial developments. Additional effects on migratory birds from collisions with structures associated with offshore developments (e.g., Northstar) also have occurred (Day et al. 2003).

Other past and present activities involve human developments and hunting associated with NSB villages, the use of the U.S. Air Force’s (USAF) Alaska Radar System sites, and ongoing scientific studies across the North Slope. Features of human developments that can affect birds include subsistence hunting and egg-collecting; sport hunting; disturbance during nesting and migration; collisions with buildings, communication towers, and power transmission lines, as well as with vehicles and aircraft; habitat loss, alteration, and disturbance associated with gravel roads/pads; and increased predation from mammal and bird predators attracted to human developments. Effects from scientific studies on the North Slope largely are restricted to disturbance to birds during nesting and migration. Outside Alaska, past and present hunting activity for some species, especially waterfowl, during the nonbreeding season contributes an additional mortality factor.

These past and present activities have resulted in documented habitat loss/alteration, disturbance, and mortality for bird species, particularly within the established oilfields (Prudhoe Bay, Kuparuk, Endicott, Milne Point), but these effects also are likely within newer fields (Alpine, Alpine satellites, Oooguruk, Northstar, Badami), and exploration areas within the NPR–A and at Point Thomson (Truett and Johnson 2000; NRC 2003). In a recent review of cumulative effects of oil and gas development on the North Slope, some bird species or species groups were identified as of conservation concern: loons, shorebirds, Tundra Swan, Lesser Snow Goose, Brant, and eiders (NRC 2003). The NRC review identified the following cumulative effects on birds from past, present, and future developments on the North Slope:

- Shifts in nesting distribution of shorebirds in response to oil field facilities;
- Artificially high predator populations (Arctic and red foxes, gulls, ravens) in the oil fields because of inadequate disposal of garbage;
- Increased predation on birds' nests and young from the higher predator numbers;
- Future development in the Brooks Range foothills could affect nesting raptors;
- Potential adverse effects on molting waterfowl, particularly Brant, if oil development occurs in the Teshekpuk Lake area within NPR–A; and
- A major oil spill associated with the shoreline or offshore that could endanger molting flocks of waterfowl in nearshore lagoons.

RFFAs that have been identified as potentially contributing to habitat loss, disturbance, or mortality effects on birds in the ROI for the Project are identified in Table 6-2. The most important RFFAs for this analysis are the potential oil and gas developments that are anticipated for the North Slope in the foreseeable future, and especially those east of Prudhoe Bay, including the possibility that the Project could be expanded to produce natural gas. Compared to non-industrial human developments and scientific studies, oil and gas development activities have the greatest potential to contribute to habitat loss, disturbance, or mortality effects on birds.

Development of the Project could be expected to contribute to most of these cumulative effects, except for the effects identified for the Brooks Range foothills and in the Teshekpuk Lake area. Appropriate mitigation measures (see Chapter 5, Mitigation) can reduce effects, but cannot completely eliminate them.

The NRC report did not analyze all possible effects on birds of global climate change, but more recent literature has described not only the warming trends in the Arctic (Kaufman et al. 2009) but also the potential effects of those trends on wildlife, including birds (USGS 2005; Martin et al. 2009; Post et al. 2009). Those studies identified the likely effects of climate change on birds including:

- Changes in waterbodies and wetland habitats (drying of lakes, water level changes, changes in drainage, changes in lake size/morphology, erosion of coastal shorelines, increases in salt-affected habitats, and drying of tundra);
- Changing vegetation structure (increases in shrub habitats, increasing salt marsh along the coast);
- Changes in bird species diversity, distribution, and abundance (emigration/immigration of species and changes in population numbers);
- Changes in predator-prey relationships (increasing predators [red foxes], changing prey populations [lemmings], changing aquatic prey species as freshwater and marine water ecosystems warm); and
- Changes in human activity and ground temperatures that affect the availability of contaminants/toxins.

All these effects involve complex interactions, and the responses of birds to each may differ across species groups and result in varying effects; thus, any conclusions about the cumulative effects of climate change and concurrent oil and gas development are tentative. For many bird species, the overall changes that might occur if warming of the Arctic continues could result in minor beneficial effects on abundance and productivity, but for some species that have restrictive habitat or food needs (which become adversely affected by habitat changes) the long-term results of climate change might be adverse. However, contributions to cumulative effects from the Project could be minor.

6.8.4.4 Conclusions on Birds

In summary, given the relatively small scale of the Project within the ROI, the Project would have a minor contribution to adverse cumulative effects on birds in the foreseeable future. The strongest effects from the Project could occur within the nearshore environment where larger numbers of birds congregate, making them vulnerable to disturbance and/or oil/contaminant spills. For most bird species using tundra and freshwater habitats on the ACP, development of the Project could result in minor contributions to cumulative effects on distribution, abundance, and productivity. Some adverse effects of the Project can be reduced through mitigation measures designed to reduce disturbance, reduce potential predator increases, and other sources of human-caused mortalities (spills, collisions).

6.8.5 Marine Mammals

6.8.5.1 Region of Influence

The ROI for marine mammals primarily includes the area immediately offshore of the Project site for most activities but also extends from Prudhoe Bay to the U.S.-Canada border. The ROI also includes the waters within the barrier islands from Prudhoe Bay to Point Thomson where materials would be barged or transported over ice roads to the Project site and east to the U.S.-Canada border. Marine mammals included in this analysis are the ring seal, spotted, bearded seal, and beluga whales. Polar bears and bowhead whales are discussed under Section 6.8.6, Threatened and Endangered Species.

6.8.5.2 Summary of Direct and Indirect Effects

The potential effects of the Project are primarily limited to seals, because whales occur beyond the barrier islands and are not present when the ocean is ice-covered from late fall to mid-spring (Greene et al. 2009; Treacy et al. 2006). Exposure of beluga whales to Project activities would be primarily limited to barge traffic for module delivery for a short period of time during the construction phase. Project activities causing potential direct effects on seals would be mainly limited to ingestion of oil spilled into the marine environment. Spilled oil of sufficient quantity entering the sea, particularly during spring break-up of the ice, could cause seal mortalities if it is ingested or fouls the fur. However, such a spill is unlikely given the Project is on land and most spills, based on past spill records from oil and gas operations on the North Slope, would be too small to enter the sea. Considering the oil spill training and preparedness of the industry demonstrated by spill history over the last 10 years, if a larger spill did occur the industry would rapidly respond and quickly contain it thereby reducing potential effects.

Indirect effects would be associated with airborne and underwater noises that could affect seals by altering behavior. The primary source of underwater noise would include vessels towing barges, while airborne noise would come from equipment and machinery at the site. Any effects would be limited to the open-water season because from winter through spring there would be no vessel activity and seals would be in lairs, which attenuate airborne sounds (Williams et al. 2006). In addition, noises produced by the project would primarily be below the frequency of optimal hearing of seals (Blackwell et al. 2004a). Furthermore, the persistent winds of the region would further dampen sounds (Blackwell et al. 2004b), resulting in a small proportion of time the Project sounds may be audible to a small number of seals near the site. Noise from aircraft is not anticipated to affect seals or other marine mammals because flights will be over land or at a high enough altitude to have no effect.

Consequently, any direct and indirect effects from the Project are expected to be minor, because the number of seals affected would be small, the intensity minor, the extent localized, and the duration temporary. Mitigation measures stipulated in permits and agreements, and those established by ExxonMobil, would further reduce any effects of the Project on seals and other marine mammals.

6.8.5.3 Cumulative Effects on Marine Mammals

Past activities (Table 6-2) of consideration in the area for marine mammals that could have affected seals include military operations, oil and gas exploration, re-start of the Badami Development, scientific research, and remediation activities in the Project area (that could have caused disturbance to seals because of increased air and vessel traffic and noise from heavy equipment). The magnitude of past effects on seals because of disturbance from these external activities is unknown, but long-term effects on species are unlikely. These activities may have caused no more than a temporary and localized effect on a small percentage of the populations of each seal species, as shown by a number of research programs examining effects of industrial activity in the Beaufort Sea concluding that such activities have no effect on seals biologically (Moulton et al. 2003, 2005). Some of these activities could not have caused any effects biologically, such as research conducted in the last 10 years, because scientific permits required for the research from the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) would have stipulated measures to ensure effects on a small number of marine mammals are minimized.

RFFAs that could potentially affect seals in the vicinity of the Project have been identified in Table 6-2. They include offshore seismic exploration and drilling outside of the barrier islands; vessel traffic; and changes in climate conditions.

These activities individually could result in temporary and short-term effects on a small number of seals in the local vicinity of the activity. Studies of seals at BPXA's Northstar Development and various seismic operations show that seals are not displaced by noises from such operations, because the sounds have no more than a short-term and temporary effect (Moulton et al. 2003, 2005; Ireland et al. 2009; Brueggeman et al. 2009). All of these operations are strictly regulated through federal permits requiring mitigation to further ensure effects are no more than negligible on the marine mammals. Changes in climate conditions may affect seals and other marine mammals, but there are insufficient data to determine the outcome of these potential effects, as discussed in the next section.

Small numbers of seals could be exposed to noise levels more frequently from equipment and machinery, and from vessel and aircraft traffic in the region, during drilling, construction, and operations. Construction and operations, more than drilling at the site, could incrementally but not substantially increase the area exposed to noise from oil and gas development along the Beaufort Sea coastline. Similarly, vessel and aircraft traffic could add geographically to the noise from other oil and gas operations. Seals seasonally and permanently inhabiting the waters within the barrier islands are expected to encounter noise more frequently from the Project and other oil and gas operations. However, the intensity would be minor, the extent localized, and the duration temporary.

Equipment and machinery noises from drilling, construction, and operations associated with the Project would be confined to a small area around the site. Most drilling and construction noise would be limited to winter, when the tundra is frozen. Operational noise would occur year-round, but at a lower level than during construction. A small number of seals could be temporarily affected by these activities during summer/fall, but there should be no effects during winter, because ringed seals occur in lairs (on the sea ice), which attenuate airborne noise (Moulton et al. 2003, 2005; Williams et al. 2006). Studies have shown that construction and operational noises are typically close to or below ambient noise close to the source in the Arctic because of the persistent winds, but on calm days may extend farther out (Blackwell et al. 2004b). There should be little to no underwater noise, because the Project would be built on land, which would prevent noise being transmitted into the water. Furthermore, any transmitted noise would be at frequencies typically below those heard by seals. If heard, such noises have not been shown to have more than a short-term affect on seal behavior (Blackwell et al. 2004a). As mentioned above, whales would not be expected to be affected by construction or operations, because they typically occur beyond the barrier islands (Greene et al. 2009; Treacy et al. 2006). Consequently, drilling, construction, and operations at the site should have no contribution to cumulative effects on marine mammals because of the low level of noise, the land-based location of the Project, the minimal hearing sensitivity of seals to low-frequency noises typical of construction and operation projects, and the considerable distance of the Project from other developments.

Vessel traffic associated with the Project is expected to be limited to within the barrier islands during summer/fall, when there is open water, with the exception of one sealift during construction seasons. Small numbers of seals are widely spaced within the barrier islands during this time period. Vessel traffic in the Beaufort Sea is variable among years, depending on numerous factors, including oil and gas activity and regional commerce. Vessel traffic sequentially decreased from 25,330 kilometers (15,739 miles) in 2006 to 11,693 kilometers (7,266 miles) in 2008, with peak traffic in August (Table 6-4; Ireland et al. 2009), however, there is some evidence that it is again increasing. Vessels servicing the Project area would add more traffic (on the basis of these data), but it is not clear if it would be higher or lower than 2008, given the annual variability. Regardless, studies of vessel effects on seals have shown that the intensity of the effect is not measurable, the extent is localized, and the duration is temporary. Seals show little reaction to moving vessels and, when they do, they quickly return to their normal behavior. Consequently, vessel noise during drilling, construction, and operations would likely have no cumulative effects on marine mammals.

Table 6-4: Estimated Number of Kilometers of Non-seismic Vessel Traffic in the Beaufort Sea, 2006-2008

Year	July*	August*	September*	October*	Total*
2006	488	16,381	8,461	0	25,330 (15,739 miles)
2007	244	10,182	3,424	0	12,850 (7,985 miles)
2008	0	1,282	3.136	1,328	11,693 (7,266 miles)

Note: * Distances shown in kilometers unless otherwise noted.

Similarly, aircraft traffic would not contribute to cumulative effects on marine mammals during the three phases of the Project, provided flights are conducted over land or, if over water, at an altitude above 1,500 feet. Studies have shown that marine mammals do not respond to aircraft flown above this altitude (Richardson et al. 1995). In addition, flights during winter over ice should have no effect on ringed seals, because they inhabit lairs which, as previously mentioned, insulate them from airborne noises, similar to polar bear dens (Blix and Lentfer 1992).

Project operations, in combination with other operations, could increase the potential for an offshore oil spill in the Beaufort Sea that could contaminate marine mammal food and soil their fur. Ingestion of contaminated food could be lethal and seals with oiled fur could suffer mortality from direct exposure to spilled oil. Major oil spills are not anticipated during drilling or construction because of the small amount of petroleum stored on site for these activities.

Spilled oil can be toxic to marine mammals (Geraci and St. Aubin 1990; Loghlin 1994; NRC 2003). Data summarized here from the NRC (2003) report document that experiments conducted of oil exposure on polar bears, seals, and pinnipeds showed adverse effects on these species, and that bears are susceptible to oil contamination. However, there is no documentation that either ringed seals or polar bears have been affected by oil spilled as a result of North Slope industrial activities (NRC 2003).

Direct effects oil spills on whales and similar effects on all marine mammals within the study area include:

- Inhalation of toxic components of crude oil;
- Ingesting oil and/or contaminated prey;
- Fouling of baleen;
- Oiling of skin, eyes, and conjunctive membranes;
- Reduced food source; and
- Displacement from feeding areas.

Indirect effects on whales and similar effects on other marine mammals within the study area include the noise and presence of vessels, aircraft, and spill response equipment, and increased human activity associated with a spill. These factors can lead to displacement from feeding areas. The potential effects of small oil spills on marine mammals include stress, disturbance, and aggravation because of contact with the oil. Large oil spills have the potential to cause effects through disturbance, displacement, loss of habitat, and mortality. Contact with spilled oil in the Beaufort Sea may cause temporary, nonlethal effects to some bowhead and beluga whales. Nonlethal effects include inhalation of hydrocarbon vapors; ingestion of oil (either directly or by contaminated prey); displacement or loss of prey; skin and sensory organ damage; and baleen fouling, which may decrease feeding efficiency.

Most spills on the North Slope have been small and on land at production facilities and pipelines, and have not spilled into the ocean (USFWS 2006). Consequently, an oil spill at the Project site is not expected to contribute to a cumulative effect on seals or other marine mammals, because such a spill is expected to be localized at the facility; temporary because it could be quickly contained and cleaned up; and have no measurable effect on marine mammals.

Changes in climate condition are affecting the Arctic by increasing sea temperatures and reducing sea ice cover (Stroeve et al. 2008). While the causes of changes in climate condition are still being debated, there is now little debate that it is occurring, and the effects are particularly apparent at higher latitudes. The MMS (2007) described numerous activities or situations related to global climate change having the potential to effect marine mammals in the Chukchi and Beaufort seas, including changes in prey, habitat, and subsistence hunting. However, NMFS concluded in its stock assessment reports that there are insufficient data to make reliable predictions of the effects of changes in Arctic climate conditions on Alaska seals and whales (Angliss and Outlaw 2008). It is likely that any effects of the Project facility, however small, could be mitigated by regulations requiring project-specific and site-specific air emissions analyses and modeling to reduce emissions. Consequently, the contribution from the Project on the cumulative effects of global warming are expected to have no measureable effect on marine mammals.

6.8.5.4 Conclusions on Marine Mammals

The contribution of the Project to cumulative effects of noise on marine mammals are expected to be no more than minor and could primarily affect seals. Seals seasonally and permanently inhabiting the waters within the barrier islands are expected to encounter noise more frequently from the Project and other oil and gas operations. However, the intensity would be minor, the extent localized, and the duration temporary. An oil spill at the Project site is not expected to contribute to a cumulative effect on seals or other marine mammals, because such a spill is expected to be localized at the facility; temporary because it would be quickly contained and cleaned up; and have no measurable effect on marine mammals. While there are the insufficient data regarding effects of climate change upon marine mammals to draw conclusions, because the Project has direct/indirect effects on changes in climate conditions of none to minor , the contribution from the Project on the cumulative effects of climate change are expected to have no measurable effect on marine mammals.

6.8.6 Terrestrial Mammals

Overall anticipated effects of the Project would be minor for most terrestrial mammals. For caribou, grizzly bears, and Arctic foxes, the effects of the Project may be greater, although for all three species the primary effects would be on local populations. Cumulative effects for all terrestrial mammal species are likely to be similar in nature and severity, but because of the broad geographic scale of potential oil and gas development, could potentially affect regional populations of some species of terrestrial mammals.

6.8.6.1 Region of Influence

Caribou

In a recent review of cumulative effects of oil and gas development on the North Slope, caribou were identified as nutritionally and culturally important to North Slope residents (NRC 2003). Four caribou herds inhabit the North Slope, recognized in part on the basis of distinct calving grounds: from west to east, the Western Arctic Herd (WAH), the Teshekpuk Herd (TH), the Central Arctic Herd (CAH), and the Porcupine Herd (PH).

For cumulative effects analysis of the Project, the primary ROI for caribou encompasses the ranges of the CAH and PH, parts of whose ranges overlap in the project footprint area. However, resource development is occurring and additional projects are planned within the ranges of all four North Slope herds. With the Project and other reasonably foreseeable projects, oil and gas development is expanding into the ranges of all four herds and into the calving areas of two (TH and CAH).

Grizzly Bears

For grizzly bears, the ROI for cumulative effects of the Project includes all North Slope regions of proposed coastal and foothills oil and gas development RFFAs between Barrow and the Refuge. Resource development substantially increases bear-human interactions and, because of the frequency of bear kills in defense of life and property, appears to create a population sink that could lead to long-term effects on grizzly bear populations on the North Slope (NRC 2003).

Arctic Foxes

For Arctic foxes, the ROI for analysis of cumulative effects of the Project includes coastal tundra and, in winter, offshore ice between Barrow and the Refuge. Arctic fox populations increase, and fox densities are higher in industrial areas of the North Slope. The use of developed sites by Arctic foxes is greater in the winter months, when natural foods are scarce. Indirect effects of the increased density of foxes include increased risk of injury or transmission of rabies to oil field personnel, periodic efforts by oil field managers to reduce populations or to remove food-conditioned or habituated animals, and adverse effects on prey populations, including nesting birds and their eggs and small mammals (effects on birds are discussed in Section 6.7.4.3).

Other Mammals

The ROI for other mammals extends from the Sagavanirktok River Delta to the border of the Refuge and inland several miles. Muskoxen are no longer present in the Point Thomson area in any numbers, and their population levels appear unlikely to increase during the reasonably foreseeable future. Similarly, wolves are uncommon and unlikely to be affected by development of the Project. The effects of the Project on other terrestrial mammals primarily would be localized and associated with direct or indirect loss of habitat, affecting small mammals with limited home ranges.

6.8.6.2 Summary of Direct and Indirect Effects

Caribou

Minor adverse effects to caribou are anticipated during the drilling phase of the Project. Much of the drilling activities would be confined to winter months when few caribou are present, although some drilling testing and other supporting activities may occur when caribou are present. Before gravel roads are constructed during winter drilling, vehicles would be restricted to ice roads and pads, primarily in the nearshore environment, and would have little opportunity to affect caribou during either calving or insect harassment. Once gravel roads are constructed, some vehicle traffic could be associated with drilling activities when caribou are present. Temporary habitat loss or alteration as a result of drilling is expected to have minor adverse effects on caribou.

During the construction phase, behavioral disturbance from equipment operation and human activity (drilling, vehicles and heavy equipment, aircraft, processing facility), resulting in altered distribution, movements, and reduced use of seasonal habitats, is anticipated to have minor to moderate adverse effects on caribou. Other adverse effects are anticipated to be minor, including habitat loss and alteration, vehicle collisions, contaminants, and spills.

The frequency of behavioral reactions of caribou to road traffic and human activities would decrease somewhat during operations, when traffic levels and on-site personnel population would decrease. However, the distribution of calving and maternal caribou is likely to be affected by avoidance of areas near roads and pipelines. Access to coastal insect-relief habitats also would be affected, although neither appropriately designed roads nor pipelines are barriers to caribou movements. Long-term habitat loss and habitat alteration caused by the Project are expected to have minor adverse effects on caribou.

Grizzly Bears

During the drilling phase, attraction to Project facilities is anticipated to have minor adverse effects on grizzly bears. Drilling activities which occur during winter months, when grizzly bears are inactive in their dens, primarily in the foothills, would have no effect on these animals. Some drilling above threshold depth could occur when polar bears are active, and a small number of bears could be attracted to human activities at the Project area. With appropriate garbage handling and management procedures, few of these animals are likely to become conditioned or habituated or require control efforts.

During the construction phase, attraction to Project facilities is anticipated to have minor to moderate adverse effects on grizzly bears. A small number of bears are likely to be attracted to human activities at the Project area. With appropriate garbage handling and management procedures, few of these animals are likely to become conditioned or habituated or require control efforts.

During the operations phase, attraction to Project facilities is anticipated to have minor to moderate adverse effects on grizzly bears. Bears would be attracted to Project facilities throughout the life of the Project. Some of these animals undoubtedly would become conditioned or habituated and require control efforts.

Arctic Foxes

During the drilling phase of the Project, attraction to Project facilities is anticipated to have minor adverse effects on Arctic foxes. Anticipated effects would occur primarily during the winter months, including attraction of Arctic foxes to drilling sites and nearshore ice roads and associated mortality, including vehicle strikes and control measures.

During the construction phase, attraction to Project facilities is anticipated to have minor to moderate adverse effects on Arctic foxes. With greater levels of human activity and permanent facilities, Arctic foxes are likely to be more attracted to the Project area during the construction phase and fox densities may peak. With the development and staffing of permanent facilities, anticipated effects would occur during all seasons. Mortality of foxes from vehicle strikes would peak during construction. Additional mortality might occur if control measures were required.

During the operations phase, attraction to Project facilities is anticipated to have minor to moderate adverse effects on Arctic foxes. The increased abundance and density of Arctic foxes in the Project area is likely to be permanent, and the attraction of foxes will continue to be greater during the winter months. Mortality from periodic control measures, either widespread or targeted at habituated or sick animals, would occur periodically, and risks associated with transmission of rabies would be a concern. Mortality from vehicle strikes would be greater during periodic maintenance or construction activities, when traffic rates are higher.

Other Mammals

Few and minor adverse effects on terrestrial mammals are anticipated during the drilling phase of the Project. The primary effect on small mammals would be temporary habitat loss and alteration from the footprints of onshore ice roads and pads. Because most traffic would be limited to ice roads in the nearshore, very little terrestrial habitat would be affected. No effects on muskoxen or wolves are anticipated.

Permanent habitat loss and alteration would increase during the construction phase of the Project, primarily affecting small mammals with limited home ranges. The attraction of Arctic foxes, ravens, and gulls to the Point Thomson area would have an indirect effect on populations of prey species, including lemmings and voles. Overall effects of the construction phase of the Project are expected to be minor for terrestrial mammals other than caribou, grizzly bears, and Arctic foxes.

Permanent habitat loss and alteration would continue to some degree through the operations phase of the Project, primarily associated with maintenance activities. Additional habitat alteration from maintenance of roads, snowdrifts, dust fallout, gravel spray, thermokarst, impoundments, withdrawal of water, or accidental contaminant spills would continue during the operations phase. The attraction of scavengers to Project facilities would continue to affect prey species, including lemmings and voles. The overall effects of the operations phase of the Project are expected to be minor for terrestrial mammals other than caribou, grizzly bears, and Arctic foxes.

6.8.6.3 Cumulative Effects on Terrestrial Mammals

Caribou

Section 6.5 provides a summary of important past and present developments and actions in the Project area. In the years since oil development started on the North Slope, long-term habitat loss caused by direct placement of gravel and gravel mining has resulted in no demonstrable effects on caribou. The combined effects of temporary habitat loss from snowdrifts, dust, gravel spray, thermokarst, impoundments, contaminant spills, or other causes also have resulted in no demonstrable effects. Behavioral disturbance in the North Slope oil fields, primarily associated with roads and pipelines, has been shown to affect habitat use by calving and maternal caribou and to affect movements and habitat use by sex-age groups of caribou during the insect season. As outlined in Section 4.2.6, research has demonstrated that female caribou with calves up to three to four weeks old tend to avoid areas within at least 1,650–3,300 feet (503–1,006 meters) (Johnson and Lawhead 1989; Cronin et al. 1994), and as far as 1.25–2.5 miles (2–4 kilometers) from active pads and roads (Dau and Cameron 1986; Lawhead 1988; Cameron et al. 1992; Lawhead et al. 2004). The clearest behavioral effect of road traffic during the insect season is reduced crossing success when caribou groups attempt to cross pipelines that are within 300 feet (91 meters) of roads with high traffic rates (15 or more vehicles per hour) (Curatolo and Murphy 1986; Curatolo and Reges 1986; 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). Research since the 1980s has led to improvements in design of infrastructure and in management practices that have reduced the potential for oil field effects on movements of caribou during the insect season. Standard practices currently include elevating pipelines to a required minimum height of 7 feet (2 meters) above the ground surface (measured at the bottom of the pipe or vibration dampeners, whichever is lower) (Curatolo and Murphy 1986; Lawhead et al. 1993; Cronin et al. 1994; Lawhead et al. 2006) and assuring adequate separation (300 feet [91 meters] minimum) of elevated pipelines from adjacent gravel roads (Curatolo and Reges 1986; Cronin et al. 1994). Even with such measures in place, however, some deflections and delays in movements of caribou seeking to cross pipeline–road corridors occur, primarily during the insect season. Despite clear effects on behavior and distribution, there is no consensus among caribou researchers regarding the extent to which oil field development on the central North Slope may have affected the population dynamics of the CAH. Finally, subsistence and sport hunting of caribou is a past and present action that affects both the CAH and PH through increased mortality.

Section 6.6 describes RFFAs that could occur in the project area for caribou. Of the RFFAs listed, those associated with oil/gas development and explorations are likely to have the greatest habitat-displacement and disturbance effects on caribou. Mortality from both subsistence and sport hunting will continue to affect caribou but the harvest levels will be regulated by the Alaska Department of Fish and Game (ADF&G).

The combined effects of listed RFFAs could increase the severity of all identified adverse effects to caribou. Assuming these RFFAs continue to incorporate footprint-minimizing and road-minimizing design features, the effects of direct and indirect habitat loss because of gravel footprints and habitat alteration could remain minor for caribou. The direct and indirect effects of behavioral disturbance could increase and further alterations of the distribution of calving and maternal caribou are likely. With development of the Project, roads and/or pipelines will have been constructed between inland and coastal habitats through nearly the entire range of the CAH (excluding only the easternmost limits of the herd’s range in the Refuge), and the listed RFFAs could further increase the densities of roads and pipelines in all portions of the range of the CAH. These conclusions are consistent with findings of the NRC (2003) that adverse effects of oil and gas development are likely to affect the distribution of calving and reduce access to coastal insect-relief habitats for the CAH and TH herds, with possible nutritional and population-level consequences. Only minor effects on the PH could be anticipated for the listed RFFAs, because only a few lie within the far western edges of the PH summer range. The few RFFAs listed for the Refuge could be expected to result in only minor contributions to the cumulative effects on caribou in the PH.

The listed RFFAs could further increase the density of roads and pipelines throughout the range of the CAH, particularly in coastal areas, but including wintering areas in the foothills, further increasing the severity of these adverse effects. The Project could facilitate the further expansion of oil development and gas development projects within the range of the CAH and PH, further increasing local effects in the calving area of the CAH. RFFAs involving oil and gas development to the west could similarly affect the TH.

Any increase in industrial activity in NPR-A and into the foothills of the Brooks Range could likely be accompanied by effects of the current warming trend, largely unpredictable, but possibly including increased levels of insect harassment, reduced access to winter forage, and decreased forage quality in calving areas (Martin et al. 2009). Reproductive status of Arctic caribou is highly correlated with the nutritional status of females (Cameron and Ver Hoef 1994), making caribou populations very sensitive to many environmental influences, including weather, vegetation, disease, and predators (NRC 2003). Because of this complexity, it will remain difficult to directly link or predict the effects of development on caribou populations on the North Slope, and consensus among researchers remains elusive (NRC 2003).

The cumulative effects of concern on caribou are the same as the direct and indirect effects of altered distribution and movements, reduced use of seasonal habitats, habitat loss and alteration, vehicle collisions, and contaminants and spills.

Overall, development of the Project could result in minor to moderate contributions to adverse cumulative effects on caribou, specifically on the CAH, whose calving and coastal insect-relief habitats could be most affected by the Project, the listed RFFAs, as well as past and present effect from oil development on the North Slope. When adding the Project to other past and present North Slope oil development projects, it is estimated that maternal caribou from the CAH could be displaced, during a 2- to 3-week period at and immediately following calving, from up to 19 percent of the calving range quantified by Wolfe (2000). On the basis of the current Project design, the Project is expected to contribute up to 1 percent of the total maximum of 19 percent displacement. With development of the Project, nearly the entire CAH could be required to cross pipelines and/or roads to access insect-relief habitat within the range of the herd.

Grizzly Bears

Section 6.5 provides a summary of important past and present developments and actions in the Project area that may have affected grizzly bears. Curiosity and unusual odors appear to attract bears to human camps and deliberate or accidental feeding is a powerful positive reward, often leading to food-conditioned animals and consequent effects on body condition, reproduction, numbers, and eventual mortality of conditioned animals through defense of life or property killings (NRC 2003). These effects have been observed during virtually all previous development projects on the North Slope, although they are best studied in relationship to oil and gas developments. It is important to note that improved garbage handling and management practices and increased enforcement of no-feeding laws have greatly reduced the severity of adverse effects, but they do not eliminate the problem of attraction of bears to areas of human activity. Sport hunting of grizzly bears, especially in the Brooks Range, and defense of life or property killings elsewhere (e.g., near NSB villages) also constitute additional mortality factors for bears.

Section 6.6 describes the RFFAs that could occur in the ROI for grizzly bears. Grizzly bears could be affected by all listed RFFAs because all forecasted activities could occur within the range of the North Slope bear population and all could increase human-bear interactions. Grizzly bear densities are higher in the foothills than on the coastal plain, and effects on grizzlies are likely to be greater with developments in the foothills. According to the NRC (2003), expanded development on the North Slope does not appear likely to have a large effect on populations of grizzly bears if proper attention is made to reducing the availability of artificial foods. Nonetheless, bears will continue to be attracted to developments, to become conditioned, and to be killed as they increasingly encounter human development and increased human populations in previously unpopulated habitats.

The cumulative effect of concern on the grizzly bear are similar to the direct and indirect effects of increased population as a result for artificial food sources, resulting in increased mortality and indirect effects of increased predation on their prey species. The cumulative effects are considered minor to moderate. Overall contribution of the Project to overall cumulative effects is considered minor.

Arctic Foxes

Section 6.5 provides a summary of important past and present developments and actions in the Project area that may have affected Arctic foxes. It is likely that fox populations have increased in association with all past and current industrial activities on the coastal plain (NRC 2003). Arctic foxes use developed sites for foraging on garbage and handouts and find abundant artificial den-like resting sites that are used year-round in developed areas. The concentration of Arctic foxes at developed sites is particularly notable during the winter months, a period when foxes in undeveloped areas typically are nomadic and remain largely on sea ice. Although development increases the local abundance of Arctic foxes, associated risks and adverse effects lead to control efforts, primarily winter kill-traps, but occasionally including relocations of individual problem animals. It is unlikely, however, that such control efforts have adverse effects on the regional abundance of Arctic foxes, and it is unclear whether increased densities in developed areas affect other aspects of Arctic fox ecology, such as disease transmission or off shore sea-ice ecosystem functions. Additional mortality of Arctic foxes, likely at a low level, may occur from local trapping efforts on the North Slope.

Section 6.6 describes the RFFAs that could occur in the Project area for Arctic foxes. Arctic foxes could be affected by all listed RFFAs that are located on coastal tundra and offshore and by all activities that increase the availability of artificial food and shelter in those habitats.

With development of listed RFFAs, the summer and winter populations of Arctic foxes likely could increase in developed areas across the ACP outside the Refuge. This conclusion is consistent with the findings of the NRC (2003), and the primary indirect effect of concern is adverse effects of fox abundance on regional populations of some species of Arctic-nesting birds. Although an increase in abundance appears likely with ongoing development on the ACP, long-term patterns of abundance are difficult to predict, particularly because of uncertainty regarding the effects of the current warming trend on Arctic foxes.

Red foxes appear to be increasing in abundance in some regions of the North Slope, expanding into Arctic fox habitats and excluding the smaller Arctic foxes from areas inhabited by red foxes. On the North Slope, the increased abundance of red foxes also may be affected by human population growth and industrial development. Another potential factor that could affect regional populations of Arctic foxes in the future is the reduction of sea ice, a critical winter habitat for Arctic foxes.

Other Mammals

Section 6.5 provides a summary of important past developments and actions in the Project area that may have affected terrestrial mammals. The combined effects of direct and indirect habitat loss for terrestrial mammals caused by past and present actions in the region are minor. The primary effects were displacement of small mammals from facility footprints, and regional population effects are unlikely.

Section 6.6 describes the RFFAs that could occur in the Project area for terrestrial mammals. The effects of the listed RFFAs on terrestrial mammals are expected to be similar to those observed for past and present actions. For terrestrial mammals other than caribou, grizzly bears, and Arctic foxes, the cumulative effects could be similar to the direct and indirect effects of habitat loss and displacement, primarily of small mammals with small home ranges. The contribution of the Project to overall cumulative effects could be minor.

Cumulative effects on terrestrial mammals other than caribou, grizzly bears, and Arctic foxes include habitat loss and displacement. Effects of the Project when added to the past, present, and the listed RFFAs on terrestrial mammals other than caribou, grizzly bears, and Arctic foxes are expected to be minor. The contribution of the Project to the overall cumulative effect could be considered minor. Although direct and indirect habitat loss is measurable, the primary effects could be displacement of mammals with small home ranges, and regional or population-level effects are unlikely.

6.8.6.4 Conclusions on Terrestrial Mammals

The Project is expected to result in behavioral disturbance, the direct and indirect effects of which could result in the displacement of some calving and maternal CAH caribou from some portions of the calving area during spring, and of caribou of all ages and sexes from insect-relief habitat during summer. These effects result in a minor to moderate contribution to the overall cumulative effects on the CAH.

Grizzly bears could be attracted to the Project and this could occasionally result in bears killed in defense of life or property. Increasing density of human development, as outlined in the listed RFFAs, could further increase bear-human interactions and related effects, particularly in the foothills where bear densities are higher. The Project could facilitate further expansion of oil development projects and the development of gas resources within the ranges of local bears, further contributing to cumulative effects.

The Project could attract Arctic foxes during both summer and winter months. During summer, the density and productivity of local breeding foxes could increase. Other listed RFFAs could further increase the regional abundance of Arctic foxes across the coastal plain outside the Refuge. Overall, the Project is expected to make a minor to moderate contribution to the cumulative effects expected on Arctic foxes.

The Project is expected to cause direct and indirect loss of habitat for terrestrial mammals, the primary effect being the displacement of mammals with small home ranges. Cumulative effects of the listed RFFAs could increase habitat loss and displacement of small mammals, but regional or population-level effects are unlikely. Overall, the Project is expected to make a minor contribution to the cumulative effects expected on small mammals.

6.8.7 Threatened and Endangered Species

The cumulative effects analysis for threatened and endangered species is divided into separate discussions for the bowhead whale, Yellow-billed Loon, Spectacled Eider, and polar bear. As described in Section 4.2.7, Steller's eiders have not been recorded in the Point Thomson area, are unlikely to occur there, and, therefore, are not included in this analysis of cumulative effects.

6.8.7.1 Region of Influence

Bowhead Whales

The ROI for bowhead whales would be considerably offshore of the Project site and extend east of the U.S.-Canada border and west along the transportation routes used by barges transporting modules and other materials to Point Thomson. This includes waters within the barrier islands from Prudhoe Bay to the U.S.-Canada border.

Yellow-billed Loons

The ROI for the Yellow-billed Loon extends from Barrow eastward to the U.S.–Canada border, encompassing most of the NPR–A, the developed oilfields, the Point Thomson region, and the adjacent Refuge. This includes a large portion of the breeding range for the Yellow-billed Loon on the ACP, with the exception of breeding areas west of Barrow. This also encompasses the exploration, construction, and operations activities associated with the active oil fields and those associated with the Project that might affect Yellow-billed Loons.

Spectacled Eiders

The ROI for the Spectacled Eider extends from Barrow eastward to the U.S.–Canada border, encompassing most of the NPR–A, the developed oilfields, the Point Thomson region, and the adjacent Refuge. This includes most of the breeding range for the Spectacled Eider on the ACP, except those habitats west of Barrow. The region encompasses the exploration, construction, and operations activities associated with the active oil fields and those associated with the Project that might affect Spectacled Eiders.

Polar Bears

The ROI for polar bears includes the entire range of the Southern Beaufort Sea (SBS) stock, extending from Point Barrow into the eastern Beaufort Sea in Canada. This encompasses the area affected by exploration, construction, and operational activities associated with the active oil fields on the North Slope, as well as offshore leasing, exploration, and potential development prospects in the Beaufort Sea (i.e., the region covered by the current Incidental Take Regulations (ITRs); Volume 64, Federal Register, Page 43925 [71 FR 43925]). Because the world-wide population was listed as threatened under the Endangered Species Act (ESA), assessment of cumulative effects also considers factors affecting the entire range of the species.

6.8.7.2 Summary of Direct and Indirect Effects

Bowhead Whales

Likely effects of the Project may be limited primarily to small numbers of bowhead whales occasionally found within the barrier islands; most bowheads frequent offshore waters from late spring to fall (Treacy et al. 2006). Vessel traffic during all phases of the Project could result in minor disturbance effects through underwater noise or possible collisions. Vessels towing barges have been shown to have no more than temporary and short term effects on bowhead whales (Richardson et al. 1995). Vessel traffic would be limited to the open water season. Aircraft noise should not affect bowheads, since flights will either be over land or of sufficient altitude to minimize effects.

Project activities causing potential mortality effects on bowhead whales would be collisions with barge traffic or oil spills. Neither of these effects have been reported in the Beaufort Sea. Spilled oil of sufficient quantity entering the sea, particularly during spring breakup of the ice, could cause bowhead mortalities if it is ingested in relatively large quantities. See Section 6.8.7.3 below for further discussion of oil spill effects.

Direct and indirect effects from the Project are expected to be none to minor (Table 4-23). The number of bowhead whales affected would be small, the intensity minor, the extent regional, and the duration temporary. Mitigation measures stipulated in permits and agreements, and those established by ExxonMobil, would further reduce any effects of the Project on bowhead whales.

Yellow-billed Loons

Overall, likely effects of the drilling, construction, and operation phases of the Project on Yellow-billed Loons may be none to minor (Table 4-25). Onshore ice roads and pads used during drilling could potentially effect Yellow-billed Loons by delaying ice melt in breeding lakes, by increasing lake-ice depth, and by withdrawal of water from lakes to construct the ice roads. All other drilling activities that occur in winter, when loons are absent from the Project area, would have no effect on this species.

Habitat loss and alteration associated with gravel placement during construction is not expected to affect Yellow-billed Loons unless gravel is placed adjacent to or in breeding lakes. Marine vessel movements and sea lift activities may disturb Yellow-billed Loons using nearshore marine waters during the construction phase.

Disturbance to Yellow-billed Loons is less likely during the operation phase. Vessel activity in nearshore waters of Lion Bay would be lower than during construction. Likelihood of disturbance by facility operations, noise, or vehicle and aircraft traffic is lessened by the lack of reported nesting of Yellow-billed Loons in the Project area. Operations activities in nearshore waters could disturb Yellow-billed Loons when they are present in summer. Direct mortality could occur from in-flight collisions with overhead powerlines, facilities, vehicles, or communication towers. Increased predation, or oil or other contaminant spills, particularly in nearshore waters, could also cause mortality.

Spectacled Eiders

Most effects of the Project on Spectacled Eiders are expected to be minor (Table 4-26). Effects from drilling activities would be limited primarily to potential temporary loss of habitats in the summer following the use of ice roads and pads. No disturbance or mortality would be associated with drilling activities during winter when Spectacled Eiders are absent from the Project area.

Habitat loss and alteration associated with gravel placement during the construction phase may have a minor effect on Spectacled Eiders. Limited numbers of eiders use the Project area, but there is no evidence for extensive nesting by eiders in the area, and the acreage affected by gravel placement is limited. Secondary effects of gravel placement (e.g., impoundments, gravel and dust fallout, and thermokarst) may affect eiders. With most construction activities scheduled during winter and the relative scarcity of eiders in the Point Thomson region, overall effects during construction may be minor.

Effects of operations activities on Spectacled Eiders include disturbance by in-field vehicles, aircraft, and noise; temporary habitat losses from snow dumps, snowdrifts, and ice roads; habitat alterations (impoundments); and direct mortality (collisions, increases in predation, and spills or contaminants). Overall effects are mostly minor, but could increase to moderate to major for major spill events.

Polar Bears

The anticipated minor effects of the drilling, construction and operational phases of the Project on polar bears are expected to be none to minor with implementation of mitigation measures required by the ITR/Letter of Authorization (LOA) process, and ESA Section 7 consultation. Refer to Section 4.2.7.2 for mitigation and consultation details. This includes effects of habitat loss and alteration during the drilling phase, effects on the productivity of polar bears in the Point Thomson area due to project-related disturbance of denning maternal females, and project-related injury or mortality effects.

Effects of construction on denning habitat are likely to be none to minor with the required mitigation in place to identify and avoid occupied dens. The heightened level of human activity during construction could increase the magnitude of disturbance effects on non-denning bears. The effects, however, are likely to be none to minor in light of mitigation measures specified in the interaction plan. The risk of injury or mortality due to the potential for increased human-bear interactions is also likely to be none to minor in view of the demonstrated effectiveness of the specified mitigation requirements.

Potential effects on polar bear habitat through loss or alteration are expected to be lowest during the operation phase of the Project. No ice roads or pads are planned and no new gravel placement will be done. The presence of facilities and associated human activity diminishes the attractiveness of some potential denning habitat in the vicinity of infrastructure. Potential denning habitat in the Point Thomson area, however, is low, so effects on habitat during this phase likely would be none to minor. Effects of disturbance in the operational phase are likely to be none to minor with required mitigation in place, although the magnitude may reach minor levels in the future with increasing terrestrial presence of bears in late summer and autumn.

6.8.7.3 Cumulative Effects on Threatened and Endangered Species

Bowhead Whales

Past activities in the area of consideration (Table 6-2) could have affected bowhead whales. These include: military operations; oil and gas exploration; and scientific research. The magnitude of past effects on bowhead whales from these external activities is unknown, but long-term effects are unlikely. These activities could have caused no more than a temporary and localized effect on a small percentage of the population. The continued increase and health of the Bering-Chukchi-Beaufort seas (BCB) stock of bowhead whales demonstrates that industrial activity in the Beaufort Sea has had no effect on this population (George et al. 2004a, 2004b; Brandon and Wade 2004). Research activities conducted in the last 10 years could not have caused any biologically effects, since scientific permits required for the research from the NMFS and USFWS would have stipulated measures to ensure no more than a negligible effect on a small number of bowhead whales.

RFFAs (Table 6-2) could potentially affect bowhead whales in the vicinity of the Project. Included are offshore seismic exploration and drilling outside of the barrier islands, and vessel traffic. Disturbance could also occur if it became necessary to dredge offshore for the Badami dock to support re-start of these facilities.

These activities individually could not cause more than a temporary and short-term effect on a small number of bowhead whales localized in the vicinity of the activity. Studies of bowhead whales at BPXA's Northstar Development and various seismic operations show that bowheads do respond to noises from such operations, but the responses have no more than a short-term and temporary effect (Richardson et al. 1995; Ireland et al. 2009). All of these operations are strictly regulated through federal permits requiring mitigation to further ensure adverse effects are no more than negligible on bowhead whales.

The Project's contribution to cumulative effects on bowhead whales is expected to be no more than minor, and could primarily involve barge traffic outside of the barrier islands but inshore of the main bowhead path during the fall migration. Small numbers of bowheads could be exposed to increased noise levels from more frequent vessel and aircraft traffic in the region during drilling, construction, and operations. The area exposed to noise from oil and gas development along the Beaufort Sea coastline could be expected to increase incrementally, but not substantially, during construction and operations, more so than during drilling. Similarly, vessel and aircraft traffic associated with the Project could add to the noise from other oil and gas operations, the nearest of which are Badami Development and Prudhoe Bay, 22 miles west and 60 miles west of Point Thomson, respectively. Bowheads inhabiting the waters within or near the barrier islands are expected to encounter noise more frequently from Point Thomson than from other oil and gas operations. Effects, however, are expected to be of low intensity, localized in extent, and of temporary duration.

Equipment and machinery noises from drilling, construction, and operations would be confined to a small area around the Project site, so such noises are expected to have no effect on bowhead whales. Moreover, most drilling and construction noise would occur in winter when bowheads are absent from the Beaufort Sea. Operational noise would occur year-round, but at a lower level than during construction. There should be little to no underwater noise emanating directly from the Project, since it will be built on land. This could minimize noise transmittance into the water. As mentioned above, bowhead whales would not be expected to be affected by construction or operations, since they typically occur beyond the barrier islands (Greene et al. 2009; Treacy et al. 2006). Consequently, drilling, construction, and operations at the site should have no contribution to cumulative effects on bowhead whales due to the land-based location of the Project and the considerable distance of the Project from other developments.

Vessel traffic associated with the Project is expected to be largely limited to within the barrier islands during the open-water season of summer/fall. Few, if any, bowhead whales occur within the barrier islands and those outside of the islands are mainly present during the fall migration when they are widely distributed over the outer continental shelf. Vessels servicing Point Thomson could add more traffic, but it is not clear if it could be higher or lower than 2008, given annual variability (see Table 6-3). Regardless, studies of effects of vessels not directly approaching bowhead whales have shown that the whales are either unaffected or temporarily affected, and at times approach to within 100-500 meters of a vessel (Wartzok et al. 1989; Richardson and Finley 1989). In addition, a Conflict Avoidance Agreement (CAA) between ExxonMobil and the Alaska Eskimo Whaling Commission (AEWC) will coordinate vessel traffic for the Project with the fall bowhead whale migration and subsistence hunt. This should alleviate potential adverse effects during much of the fall migration. Consequently, vessel noise during drilling, construction, and operations may have a minor contribution to cumulative effects on bowhead whales.

Similarly, aircraft traffic is not expected to contribute to cumulative effects on bowhead whales during the three phases of the project, provided flights are conducted over land or, if over water, at an altitude above 1,500 feet (457 meters). Bowhead whales do not respond to aircraft flown above this altitude (Richardson et al. 1995).

Point Thomson operations, in combination with other operations, may increase the potential for an offshore oil spill in the Beaufort Sea. Ingestion of contaminated food or spilled oil could be lethal to a small number of bowhead whales. Major oil spills, however, are not anticipated during drilling or construction due to the small amount of petroleum stored on site for these activities. The potential adverse effects of an oil spill on bowhead whales depend on a variety of factors including the size, sea conditions, time of year (open water, broken ice, solid ice cover), and quickness of industry to contain and clean up the spill.

There are no data about Arctic oil spills and their effect on bowhead whales because no major oil spill has occurred in the Beaufort Sea. However, the potential for an oil spill and its likely effects on bowhead whales are viewed by bowhead-dependent hunters as the greatest threat to the whale population and to their cultural relationship with the animal (Ahmaogak 1985, 1986) following a large spill.

Contact with spilled oil in the Beaufort Sea may cause temporary, nonlethal effects to some bowhead whales. The amount of oil required to kill a whale is not known. Nonlethal effects include inhalation of hydrocarbon vapors; ingestion of oil (either directly or by contaminated prey); displacement or loss of prey; skin and sensory organ damage; and baleen fouling, which may decrease feeding efficiency, and displacement from feeding areas.

Since Point Thomson will be located on land, it is likely that any spill would be small and quickly contained by industry before entering the sea. Most spills on the North Slope have been small and on land at production facilities and pipelines, and have not entered the ocean (USFWS 2006). Offshore spills are not likely within the Project area, and even less likely within the whale migration corridor located outside the barrier islands. In addition, exposure would be limited to only a small portion of the population since bowheads are widespread over a broad area. The contribution of oil spills from operations at Point Thomson on cumulative effects on bowhead whales is, therefore, expected to be minor.

Yellow-billed Loons

Past and present activities in the ROI for Yellow-billed Loons may have caused additional habitat loss/alteration, disturbance, or mortality for this species, particularly development in the Colville River Delta and NPR–A, where loons are more abundant (see Table 6-2 and Section 6.5).

The magnitude of past/present effects on Yellow-billed Loons due to disturbance or habitat loss/alteration from many of these activities is unknown. Lingering effects from any or all of these past/present actions are possible. Yellow-billed Loons are harvested by subsistence hunters in western Alaska at variable annual levels. Recent harvest increases prompted the U.S. Geological Survey (USGS) (Schmutz 2009) to evaluate the potential effect of different scenarios of harvest on Alaska Yellow-billed Loon populations (e.g., those breeding on the ACP and Kotzebue area). The USGS modeling study suggested that current levels of harvest could result in a 50 percent reduction of this population in 15 years, certainly a threat to a species that already warrants listing under the ESA. It is, thus, reasonable to assume that past and present actions adversely affect the regional population of Yellow-billed Loons, primarily through increased adult mortality. RFFAs that have been identified as potentially contributing to habitat loss, disturbance, or mortality effects on Yellow-billed Loons in the vicinity of the Project are identified in Table 6-2.

Cumulative effects on Yellow-billed Loons could occur from a combination of adverse effects associated with habitat loss/alteration, disturbance, and/or mortality. The analysis of potential effects associated with Project activities and facilities include the potential for disturbance and mortality of Yellow-billed Loons in the nearshore waters of Lion Bay. Since Point Thomson is not a major breeding area for Yellow-billed Loons, onshore activities are unlikely to contribute to cumulative effects for this species, other than the potential for mortalities of loons striking towers or facilities during migration.

An additional concern for Yellow-billed Loons could be the potential effects of change in climate conditions on nesting lakes and nearshore habitats. Nesting Yellow-billed Loons use lakes deep enough to support prey populations of fish and invertebrates, which could be affected by long-term climate changes that change lake size and morphology (e.g., water depth, water temperature, shoreline structure), lake and river connections (tapping), winter ice cover, and prey composition (Earnst 2004; USFWS 2006, 2009; Martin et al. 2009). Also of concern could be climate-change effects in the nearshore marine ecosystem used by non-breeding and post-breeding loons (such as Lion Bay), where changes in summer and winter ice distribution could affect marine prey species used by loons (USFWS 2009). Yellow-billed Loons may be less vulnerable than other species (see Spectacled Eiders below) to climate changes in their wintering areas, because they are dispersed through the North Pacific from the Russian Far East to Alaska and southward into Asia (Yellow Sea, Japan) (USFWS 2009).

The effects of oil spills warrants consideration. Small spills may have direct and indirect effects on birds. Small volumes of oil may be released from leaking tanks and valves, accidents during loading and offloading, and flushing of tanks and bilges. In cold climates, an oil spot the size of a square inch is enough to compromise water repellency of plumage, possibly leading to the death of the bird, if rehabilitation is not conducted. In some places, low-volume, chronic oiling is a major cause of seabird mortality (MMS 2008).

Potential effects on birds from large spills include adverse effects on feather insulation and acute and chronic toxicity from ingestion and absorption. Oiled birds could carry oil to nests where eggs and young could be indirectly affected with oil. The combined effects of oiled plumage, osmotic and thermal stress, and anemia could increase the mortality of birds under adverse environmental conditions. It should be noted that while spills can occur on land or in the marine environment, spills to the marine environment have the greatest potential to affect large numbers of birds (MMS 2008).

The cumulative effect on birds of small oil spills from the Project could be none. Small spills at Point Thomson would be primarily at the gravel pad, localized and contained, and not likely to enter into bird habitats.

The effect of a large spill at the Project is expected to be minor, localized, and short-term. Therefore, the cumulative effect is expected to be minor. Bird mortality from small spills, whether originating from field pipelines or spills of refined products, is expected to be prevented by expedient clean-up.

As noted above, past and present actions currently are adversely affecting the regional population of Yellow-billed Loons (primarily from adult mortality), so any additive increases in mortality associated with the Project are expected to adversely affect this population. The most likely Project activities that could increase loon mortality in the Project area are: 1) collisions of Yellow-billed Loons with Project infrastructure; 2) oil or contaminant spills in the Lion Bay area during sealifts; and 3) spills during winter use of the offshore sea-ice road (if those spills were not adequately cleaned-up before break-up of nearshore ice).

Spectacled Eiders

Past and present activities in the ROI for Spectacled Eiders may have caused additional habitat loss/alteration, disturbance, or mortality for this species (see Table 6-2 and Section 6.5). These include: military operations; oil and gas exploration in the NPR–A, Alpine, Kuparuk, Prudhoe Bay/Endicott, Badami, and Point Thomson areas; construction and operation of the Badami Development; scientific research and surveys that caused disturbance and mortality; and subsistence hunting. While Spectacled Eiders are not specifically targeted by subsistence hunters, small numbers may be taken when hunting other eider species.

The magnitude of effects on Spectacled Eiders from many of these past/present activities is unknown, but lingering effects from any or all of these actions are possible and may have contributed to current population levels. From a conservative perspective, past and present actions are, therefore, assumed to have had some lingering adverse influence on the Spectacled Eider population in the region due to habitat loss/alteration, disturbance, or mortality.

RFFAs identified as potentially contributing to habitat loss, disturbance, or mortality effects on Spectacled Eiders in the vicinity of the Project are identified in Table 6-2.

Based on analysis of potential effects associated with Project activities and facilities during the drilling, construction, and operations phases, in conjunction with effects from present and potential future external actions, cumulative effects on Spectacled Eiders may occur from a combination of adverse effects associated with habitat loss/alteration, disturbance, and/or mortality. Any potential effects from change in climate conditions on Spectacled Eiders are unclear. As described previously for birds (see Section 6.8.4), effects of climate change in the Arctic on bird species are complex, with both potentially positive and adverse influences on species abundance, distribution, and productivity (Martin et al. 2009). Effects of climate change on breeding populations of Spectacled Eiders on the coastal plain are uncertain, but some changes in the availability of breeding habitats could increase nesting areas for eiders (e.g., increases in abundance of drained-lake basin habitats, if large lakes begin draining following shoreline erosion; [Martin et al. 2009]). Conversely, climate-associated changes in predator abundance (foxes), prey abundance (invertebrates), and vegetation might have adverse effects on breeding Spectacled Eiders (Martin et al. 2009; Post et al. 2009). Spectacled Eiders also are vulnerable to climate changes that affect winter sea ice in the Bering Sea, the primary wintering area of this species (Petersen et al. 1999). Changes in sea ice distribution and polyna formation that could affect access of eiders to winter food sources might cause increased winter mortality (USFWS 1999). Uncertainties associated with potential effects of climate change on Spectacled Eiders makes determining the contribution of the Project development activities to overall cumulative effects difficult. Any positive effects on eiders associated with climate change could offset some adverse effects of human developments, or adverse changes associated with both climate change and developments could accelerate or compound population-level effects on eiders.

The effects of oil spills warrants consideration. Refer to the above section on Yellow-billed Loons for discussion of general effects on birds from small and large spills.

Spectacled Eiders are known to nest in the vicinity of the Badami Development. 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, if present in the area of the spill. The cumulative effect of numerous small spills projected over the entire life of oil and gas projects considered in this cumulative analysis could more likely result in greater mortality rates than that from a Project pipeline leak near Badami, given that evidence does not suggest a large nesting population of eiders occurs in the Project area. 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, Spectacled Eider mortality could occur (MMS 2001). Point Thomson is not expected to contribute much to the cumulative effect of oil spills on Spectacled Eiders because of the rarity of Spectacled Eider occurrence in the Project area.

Overall, the contributions to cumulative effects on Spectacled Eiders from development of the Project are considered minor. The rationale for this determination is based on the following assumptions:

- Incremental effects because of Project development are expected to be none to minor for habitat loss/alteration, disturbance, and mortality (except for large oil spills).
- The Point Thomson region is a marginal use area for Spectacled Eiders; the area is at the eastern edge of the species' range.
- Nesting habitats for Spectacled Eiders in the area are not limiting, and evidence does not suggest a large nesting population of eiders occurs in the Project area.
- Any new developments could minimize gravel footprints and mitigate effects to Spectacled Eiders (following guidelines of USFWS).
- Mitigation and avoidance of any observed Spectacled Eider nest sites can be used to minimize disturbance effects.
- Surveys for Spectacled Eiders would be conducted in the Project area to determine relative abundance and distribution of eiders and help determine if nesting sites in the vicinity of development areas are used; if use is occurring, then those areas would be protected.
- The level of mortality from subsistence hunting or scientific surveys would not contribute to population-level effects.

Polar Bears

Most of the past and present actions in the ROI have occurred onshore in terrestrial habitats that generally receive less use by polar bears than do marine habitats offshore. The notable exceptions to this generalization are the activities associated with leasing by MMS and seismic exploration in nearshore waters and over the continental shelf (e.g., MMS 2008). For instance, the Endicott and Northstar islands, located offshore from the Prudhoe Bay oil field, have recorded the highest incidences of polar bear sightings and non-lethal hazing incidents in recent years (USFWS 2009). Analysis of the cumulative effects of oil and gas leasing, exploration, development, and production by the NRC (2003) concluded that "industrial activity in the marine waters of the Beaufort Sea has been limited and sporadic and likely has not caused serious cumulative effects to ringed seals or polar bears".

The overall effects of habitat alteration or loss, disturbance, and injury or mortality of polar bears from past and present actions in the ROI have been determined to be negligible, on the basis of USFWS analyses for the current ITRs (USFWS 2006; 71 FR 43925), the ESA listing decision (Schliebe et al. 2006; 73 FR 28212), and subsequent Biological Opinions for the ITR process (USFWS 2006, 2008) and for marine leasing and exploration (USFWS 2009). The principal reason behind the negligible-effect and no-jeopardy findings of those reviews is the availability and implementation of effective mitigative measures (described earlier in Chapter 4), which are stipulated under the ITR/LOA process and have been included in the bear interaction plans required by the LOAs issued for various projects since 1991 in the Chukchi Sea and 1993 in the Beaufort Sea.

In the past, human polar bear harvest had major adverse effects on the SBS population stock, but those effects were reversed by the hunting restrictions put in place after the passage of the Marine Mammal Protection Act (MMPA) in 1972 (Amstrup 2003; USFWS 2009). The SBS stock subsequently recovered by the 1990s, but has since begun to show signs of decline concurrent with habitat changes that have been attributed to climate change (USFWS 2009). The combined harvest level in Alaska and Canada, which averaged 53.6 bears annually during 2003–2007, exceeds the annual Potential Biological Removal (PBR) level of 22 bears calculated under MMPA regulations for the current population estimate of approximately 1,500 bears (USFWS 2009).

Factors such as attraction of polar bears to areas of human activity, behavioral disturbance by humans, and site-specific contamination generally have not had population-level effects, although concerns have been expressed about the effects of general contamination from widespread pollutants, especially chlorinated hydrocarbons (organochlorines), in the atmosphere and food webs in the Arctic (Amstrup 2003; Aars et al. 2006).

RFFAs/events that have been identified as potentially contributing to habitat loss/alteration, disturbance, and injury/mortality effects on polar bears in the region of influence are identified in Table 6-2.

By far, the greatest concern regarding cumulative effects of human actions on polar bears has focused on the rapid decline of Arctic sea-ice cover, especially during the summer, which has been linked to climate warming as a result of human activities (Arctic Change Impact Assessment [ACIA] 2005; Intergovernmental Panel of Climate Change [IPCC] 2007). Various analyses of the effects of declining sea-ice cover have been discussed extensively in the scientific literature and were a major focus of the status review (Schliebe et al. 2006) and the nine reports prepared by USGS (discussed in the Polar Bear section of Chapter 3) as background for the USFWS decision to list the species as threatened under the ESA. The analytical review conducted for the ESA listing (summarized by Schliebe et al. 2006; 73 FR 28212) described the observed effects on polar bears from climate change: increased movements; changes in distribution and access to prey; alteration of denning areas and access to them; increased open-water swimming; and associated demographic changes in the bear population, as well as reductions in the availability, productivity, and access to prey populations (primarily ringed and bearded seals). USGS researchers and other polar bear experts produced seasonal habitat models, on the basis of resource selection functions developed from radio-collared bear locations and environmental data, and then compared those habitat models with the predicted distribution of Arctic sea ice over the next century from 10 general circulation models developed by the IPCC (2007) for the Arctic Ocean (Durner et al. 2009). It has been noted that the declines in sea-ice cover during summer observed recently have occurred at a rate exceeding that predicted by the suite of IPCC general circulation models (Stroeve et al. 2007), so the habitat-change predictions based on those models may underestimate the changes in sea-ice habitat. The predicted decline of ice cover could be substantially greater in summer than in winter, resulting in substantial contraction of summer ice cover into the Canadian High Arctic and northern Greenland (Convergent ecoregion) later in the century. The predicted contraction of summer ice cover could be greater in the Divergent ecoregion, in which the Alaska stocks of polar bears reside. Consequently, Durner et al. (2009) predicted that the range of the polar bear is likely to shrink along with the contracting ice cover, because of the energetic demands of traveling the long distances required to continue using the traditional areas of the species range that are predicted to experience total loss of summer ice. Polar bears may be forced either to travel with the contracting ice cover to high latitudes into areas with low productivity and prey availability, or else remain in traditional ranges by summering on land and fasting until winter sea ice forms.

The other four factors analyzed by USFWS for the ESA listing decision were regarded as being of much less concern than are the effects of Arctic climate change (Schliebe et al. 2006; 73 FR 28212). Human harvest and lethal incidental take of polar bears currently are not considered to be as important as climate change and the risk of a major marine oil spill, even though the current take exceeds the PBR level for the SBS stock. USFWS concluded that “overutilization” (all human-caused take combined) did not “threaten the polar bear throughout all or a significant portion of its range” (73 FR 28280). Nevertheless, the potential for human polar bear harvest to affect the population, especially in view of likely population declines in the future and possible synergistic effects combined with habitat loss from climate change, could result in further evaluation of management effectiveness and the sustainability of harvest levels. The potential for lethal take in defense of life around local communities, as well as industrial sites, is being evaluated by USFWS in current conservation planning efforts (Miller 2009). Disease and predation were not considered to pose a threat to the well-being of the species, although potential concerns exist if climate warming leads to the spread of pathogens and increased incidence of intraspecific predation (cannibalism) (73 FR 28281). The existing national and international regulatory mechanisms governing the management of polar bear populations were judged to be effective, with one crucial exception: “…there are no known regulatory mechanisms in place at the national or international level that directly or effectively address the primary threat to polar bears—the rangewide loss of sea ice habitat within the foreseeable future” (73 FR 28288).. Lastly, the USFWS evaluation of other factors (contaminants, ecotourism, and shipping) concluded that they do not pose a threat to the polar bear population at current levels, but may become more important in the future as polar bear distribution changes and declining populations become more nutritionally stressed as a result of expected environmental changes (73 FR 28292).

The cumulative risks from oil spills to polar bear habitats within the ROI are lower than risks from other contributing activities. The majority of polar 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 screeding. Oiling reduces the insulation quality of the fur and could cause major adverse thermo-regulatory effects. 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 clean-up activities.

Several reviews and analyses have commented on the potential for future cumulative effects to increase as a result of expanding oil and gas activity in the Beaufort Sea region (Amstrup 2003;

NRC 2003; USFWS 2008, 2009). A major concern focuses on the risk of a major oil spill, which is considered to be increasing in probability as a result of the growing number of exploratory wells and development prospects in the marine environment of the Beaufort Sea source. USFWS commented in the listing notice that "the greatest concern for future oil and gas development is the effect of an oil spill or discharges in the marine environment affecting polar bears or their habitat" (73 FR 28265). Developments located on the mainland, such as the Project, are of much less concern in this regard. The probability of a large spill within the ROI is low, so the potential for polar bears to contact spilled oil from this Project is also low. The Project's contribution to the cumulative effect on polar bears from spilled oil is, thus, considered to be minor.

6.8.7.4 Conclusions on Threatened and Endangered Species

Bowhead Whales

Contributions of the Project to cumulative effects on bowhead whales are expected to be none to minor and could primarily affect whales outside of the barrier islands during the fall migration. Mitigation measures, such as the Conflict Avoidance Agreement, could decrease potential adverse behavioral disturbance effects of vessel traffic during much of that time. Bowheads inhabiting the waters within or near the barrier islands are expected to encounter more frequent noise from the Project. Effects, however, are expected to be of low intensity, localized extent, and temporary in duration, plus only affect a small number of whales within the barrier islands. Drilling, construction, and operations at the site should have no contribution to cumulative effects on bowhead whales due to the land-based location of the Project and the considerable distance of the Project from other developments. Development of the Project may increase the potential for an oil spill. Offshore spills, however, are unlikely within the Project area and even less likely within the whale migration corridor located outside the barrier islands. Therefore, the cumulative effects of oil spills from operations at Point Thomson on bowhead whales are expected to be minor.

Yellow-billed Loons

The development of the Project is expected to have few adverse effects on Yellow-billed Loons unless increased mortalities occurred from a nearshore oil spill or a large number of loon mortalities occurred from collisions with Project facilities. Both of these scenarios are considered unlikely; thus, the overall contribution of the Project to adverse cumulative effects on Yellow-billed Loons could be considered minor. The effects of additional future developments, and in particular climate-change effects, could raise the overall expected effect to moderate if nesting habitats for Yellow-billed Loons are affected on a large geographic scale within their breeding range.

Spectacled Eiders

Development of the Project is expected to make a minor contribution to adverse cumulative effects on Spectacled Eiders. However, the cumulative effects of additional future developments, and in particular, climate-change effects, could be moderate to major. The potential adverse effects of the Project might be reduced with the implementation of selected mitigation measures.

Polar Bears

The development of the Project is expected to make a none to minor contribution to adverse cumulative effects on polar bears, because of its onshore location and the effectiveness of current mitigation. No beneficial or countervailing effects are considered likely. The potential adverse effects of the Project can be reduced by implementing the mitigative measures required by the ITR/LOA process, as specified in the bear interaction plan for the Project. The effects of continuing climate change pose major challenges to the future well-being of the species, has been predicted by some observers to lead to major population declines and range contraction within the next 50–100 years, but the ability of federal agencies to influence the processes thought to be responsible for climate change are extremely limited at present. By comparison, the cumulative effects of past, present, and reasonably foreseeable future industrial activities associated with oil and gas exploration, development, and production are of substantially lower magnitude. The combined effects of RFFAs, particularly those located in the Arctic marine environment, may contribute to adverse effects on the polar bear population in the future, primarily through the increased risk of a major oil spill.

6.9 HUMAN RESOURCES

The “Human Resources” component of this document focuses on seven topical areas for the cumulative effects analysis associated with the Project – socioeconomics, cultural resources, subsistence and traditional land use, land use and ownership, recreation, visual aesthetics, and environmental justice. These categories exhibit considerable overlap, and although they are not conceptually equivalent in terms of defining characteristics, in aggregate they encompass the foreseeable potential cumulative effects to which the Project may contribute within the “region of influence” for each topic. It should be noted that contributions to potential large-scale effects such as climate change are considered in this document at the level of the human environment only in a summary fashion. Community relocation due to increased coastal erosion, or subsistence harvest failures due to changing sea ice conditions, would be examples.

Table 6-2 contains summary descriptions of the external factors under consideration for cumulative effects analysis. Not all of these RFFAs are equally pertinent to all of the resources or potential effects discussed in this section. In order to reduce redundancy in the following sections, the following will be assumed to be the case for the remainder of Section 6.9. The elements of the Project that could have an effect on the human environment include: development and operation of a new industrial oil and gas production location and associated support infrastructure, construction and operation of oil and gas transportation (pipeline) facilities, and an additional source of employment (jobs) and revenue. Past and ongoing activities that may contribute to cumulative effects on the human environment include oil and gas exploration and development, tourism and recreation, hunting (sport and subsistence), tax and other fiscal policies (borough, state, national), community development projects, area-wide transportation modes, and large-scale or global processes such as climate change or patterns of industrial pollution. RFFAs include the continuation of all of these elements. To the degree possible, within the limits of information available and the generally broad level of analysis required for this section, the discussions below identify those RFFA most pertinent for any given resource or issue.

As with other sections of the cumulative effects analysis, the ROI will vary for each of the seven topic areas. For example, some cumulative effects occur on a statewide basis, while others are relevant to only a portion of the North Slope.

6.9.1 Socioeconomics

Analysis of potential cumulative socioeconomic effects associated with the Project concentrates on three areas – population, employment and income, and public revenues and expenditures.

6.9.1.1 Region of Influence

Population

Population effects associated with the Project can be seasonal (e.g., for winter construction activities); temporary (e.g., during construction and start-up), or permanent. Effects on population changes in small communities may be different than those in larger communities. With regard to the ROI, potential population and employment effects are evaluated at the village, borough, and statewide levels. Larger-scale population changes (village relocation due to coastal erosion, population movement and economic dislocation due to sea level rise or changes in weather patterns) are only briefly discussed.

Employment and Income

Key factors of this cumulative effects analysis are numbers and types of jobs and per capita income in the NSB and statewide. With regard to the ROI, these effects are evaluated at the community, borough and statewide level. In addition, some attention is devoted to “net benefit to the nation” but, as with only larger-scale cumulative effects, this is only briefly discussed.

Public Revenue and Expenditures

Key indicators of potential cumulative effect are changes to property tax revenues and oil royalties. These effects are evaluated at the borough and statewide level. In addition, some attention is devoted to “net benefit to the nation” but, as with only larger-scale cumulative effects, this is only briefly discussed.

6.9.1.2 Summary of Direct and Indirect Effects

Population

For a detailed discussion of the potential direct and indirect effects of the Project on population, see Section 4.3.1.1. The principal effects can be summed up as population change in the state, the NSB, and in individual North Slope villages resulting from jobs created through the construction and operation of the Project. Large, rapid population increases and decreases can have indirect effects on public services such as health, public safety and education. Because the Project is an “industrial enclave” development with a rotating workforce and no road connections to North Slope communities or the rest of Alaska, and these effects are expected to be minor at all levels.

Employment and Income

For a detailed discussion of the potential direct and indirect effects of the Project on employment and income, see Section 4.3.1. The principal effect can be summed up as job creation on the North Slope from drilling, construction, and operation activities; the Project has high state-hire targets, benefiting the residents of the NSB and the state. Because of the relatively small labor force required by the Project (a peak workforce of approximately 450 during construction and averaging 75 during operations), direct effects at the state and regional level will be beneficial but relatively minor. Assuming an indirect employment multiplier of 1.9 to 2.1, indirect effects at the state and regional level will also be beneficial but relatively minor. The level of North Slope resident local hire and service contracts awarded to Alaska Native corporation subsidiaries cannot be predicted at this time, but income from North Slope employment opportunities supports local subsistence activities and contributes to community stability, and could be beneficially minor to moderate at the community level. The extent of this benefit will depend on the design and implementation of hiring and training programs aimed at fostering local community hire.

Public Revenue and Expenditures

For a detailed discussion of the potential direct and indirect effects of the Project on public revenue and expenditures, see Section 4.3.1.3. The vast majority of borough and state revenues are generated by oil and gas facilities and production on the North Slope of Alaska. The principal effects of municipal and state revenue and petroleum production royalties from the Project are predominantly beneficial, and can be summed up as:

- The Project will add approximately $1 billion to the NSB and state taxable property (note that the NSB estimated total fiscal year 2007-2008 assessed property values at $12.9 billion, resulting in approximately $213 million in general revenue from property taxes, [NSB 2008]).
- The non-resident workforce is considered local population and will result in a minor increase in the population figure used by the NSB to calculate the allowable per capita tax limits on property.
- Increased funding for municipal employment, capital improvement plans, and health and social services through incoming public revenue to the NSB and the state derived from Project taxation and gas royalty revenue.
- Offset of decreasing oil and gas tax base for the NSB and the state.
- Some increase in public expenditures associated with permitting, regulatory oversight, and municipal services.

These beneficial effects are expected to be minor at the state level, although they offset declining oil production to some degree. Beneficial effects will be moderate on the regional NSB level and through the regional provision of services and funding to NSB communities, such as education, public safety, and health and social services.

6.9.1.3 Cumulative Effects on Socioeconomics

Population

Cumulatively, oil and gas exploration and development on the North Slope has directly affected the population of the NSB by providing direct and indirect employment opportunities and funding municipal services. Employment, income, and tax revenues have allowed village and regional populations to remain relatively stable, and attracted some new residents. The NSB derives most of its revenues from taxes of oil and gas facilities, and provides most of the employment in NSB communities (including Kaktovik and Nuiqsut). Village corporations also provide a substantial part of village employment, and in both Kaktovik and Nuiqsut have several joint ventures and/or subsidiaries in the oil support sector. A high percentage of the North Slope industrial labor force is composed of Alaska residents, but the most are not residents of the NSB and commute between the North Slope and their areas of residence.

A short-term increase in NSB population may occur during construction phases of current and proposed projects because such activities generally require increased personnel. This could be especially true for the construction of a major natural gas pipeline, although the effects could likely be less than the original TAPS construction effects. It is likely that some percentage of these jobs will be filled by local residents, thus decreasing the potential for a population influx and stabilizing village populations to some degree. However, the larger the demand for labor at any given time, the less likely that the limited Alaska labor force will be able to buffer the need to import labor from outside Alaska. In the long-term, while few people will be required on-site to maintain operation of facilities associated with a natural gas pipeline, the experience of past "boom" projects (such as TAPS) is that some out-of-state workers attracted to such temporary projects stay in Alaska once the project is completed. It is likely that these projects will have little relative effect on NSB population, but they could have an effect on the overall State of Alaska population, especially on the larger urban centers and their environs.

Within individual villages, even a small fluctuation in population can be a major effect. However, present or projected oil and gas development is unlikely to result in a direct population increase, and may stabilize populations by providing direct and indirect employment and income. The villages of Nuiqsut and Kaktovik are some distance from potential future projects and are generally inaccessible by road (Nuiqsut being reachable by a seasonal ice road in the winter). Further, housing availability in these communities is extremely limited and could not support a large population influx. However, the availability of oil and gas employment could result in minor an indirect effect on the village populations.

With respect to the state, most employees commute to North Slope work sites, and North Slope projects rely on management, personnel and support services that are often located in Anchorage or Fairbanks. Given past, present, and RFFAs and events, along with the historically high percentage of Alaskan resident hire, the expected cumulative effect on population could be none to minor. On the basis of local billeting and rotational scheduling of the workforce associated with most oil and gas exploration and development projects in the North Slope, and the relatively low level of equipment, supplies, and services provided locally, the cumulative effect on the population in local communities is expected to be minor.

The large-scale effects of global climate change could have population effects on coastal Alaskan communities within the NSB, due to increased coastal erosion and rising sea levels. Several such communities may have to relocate within the next five to ten years. This could represent a major adverse effect on NSB population, but one to which the Project could contribute a potentially minor beneficial offset.

No other external factors are considered important to this analysis of cumulative population effect in individual communities, the NSB or the state.

Employment and Income

New oil and gas projects will require the construction of additional industrial infrastructure, and could help to offset the decrease in NSB property tax revenue due to depreciation of the existing oil and gas industrial facilities. The NSB employs about two-thirds of the resident workforce (Section 4.3.1.), and a decline in NSB revenue may make continued residence in the villages more challenging. However, to the extent that reasonably foreseeable oil and gas projects increase the revenue of the NSB, and thus indirect and possibly direct local NSB employment, they have the potential to positively affect Alaska Native village populations by offsetting current trends.

External factors, in combination with the Project, appear likely to moderate to major benefit the economic environment in the NSB. The further exploration and development of oil and gas projects on the North Slope (Badami re-start, the Liberty Development, Point Thomson gas sales, offshore seismic exploration and drilling activities) has the potential to provide a major increase in employment opportunities 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 be taken by residents during the construction phases, where greater job opportunities and the seasonal nature of employment is better suited to the subsistence lifestyle, than the long-term operations jobs. Nonetheless, the development of a number of such projects could represent a major cumulative benefit to NSB residents for some years to come.

With the current forecast of reduction in NSB revenue over the next years because of decreasing returns on property tax revenues from existing oil and gas facilities, the importance of the NSB as a regional service provider and employer, the role of new revenues from developing oil and gas projects in offsetting any reduction in NSB jobs represents a major beneficial cumulative effect. Viewed cumulatively, the project provides a moderate beneficial contribution to the net climate for employment and income in the NSB,

The state also benefits from job creation and employment related to North Slope oil and gas development. Further, the oil and gas development projects positively affect the state economy because of the demand for additional public and private sector management employment and support services located around Anchorage and Fairbanks. 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 major beneficial effect by maintaining or direct and increasing indirect employment.

Media attention on the Refuge and potential effects of changing climate conditions has increased tourism and recreation to the area, the benefits of which are mainly captured by Alaska firms (including some businesses in Kaktovik and Barrow) that operate tours of the Refuge. Although these effects could be beneficial, a more comprehensive analysis would be required to quantify these activities within the larger scope of the state economy.

In sum, beneficial cumulative effects on employment and income for the NSB and NSB communities of the RFFAs are expected to be moderate to major, although the contribution of the Project is minor to moderate.

Public Revenue and Expenditures

Because the NSB is the municipal entity that taxes oil and gas property on the North Slope, the geographic scope for cumulative effect analysis includes the entire borough. Similarly, the state receives revenue from taxation and royalties associated with North Slope oil development. 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 the state. In addition to past declining revenue from reduced oil production and facility property values, present and reasonably foreseeable activities include Badami re-start, the Liberty Development, and Point Thomson gas sales and an Alaskan gas export pipeline.

The Project, in combination with other pending North Slope oil and gas development, could result in major cumulative benefits to both the NSB and the state by providing revenue from development of oil and gas resources. Within the NSB, property tax revenues fund capital project programs, amortization of debt, education, and health and social services, and result in the employment of NSB residents. Point Thomson and other reasonably foreseeable oil and gas infrastructure (and perhaps especially a natural gas pipeline to the Lower-48, for which Point Thomson gas may be a major enabling factor) would partially offset a decline in NSB revenues associated with the decline in property value on the North Slope. Gas condensate production from the project would help extend the life of TAPS and the economic benefits to the NSB. The current decline in revenues makes it difficult to implement new NSB capital projects and maintain current levels of service and employment. The contribution to beneficial cumulative effects from the Project are expected to be long-term (i.e., for the life of the Project).

Similarly for the state, 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. To the extent that Point Thomson gas is an enabling factor for a natural gas pipeline to the Lower-48, it can be expected to increase the incentive for oil explorers to develop other oil/gas prospects that would be marginal without a gas export pipeline. This would maintain the throughput of TAPS at a higher level than would otherwise be the case and result in higher overall revenues to the State of Alaska.

In sum, beneficial cumulative effects on public revenue and expenditures for the State of Alaska, the NSB, and NSB communities of the RFFAs is expected to be moderate to major, although the contribution of the Project is minor.

6.9.1.4 Conclusions on Socioeconomics

Due to the influences of the past actions and RFFAs, overall cumulative effects on population will be minimal. The beneficial cumulative effects of past actions and RFFAs on fiscal factors – employment, income, public revenue, and public expenditures – can be expected to be moderate to major. The Project is only a small part of this, however, and would contribute to a minor degree. To the extent that the Project is an “enabling” agent for other development such as a gas pipeline to the lower-48 or offshore gas development, it may be credited with additional positive effects, but currently there is no way to adequately evaluate such factors.

6.9.2 Cultural Resources

Key factors in the potential cumulative effects analysis include changes to historic sites, archaeological resources, and traditional cultural properties.

6.9.2.1 Region of Influence

The ROI for cultural resources is the universe of sites (identified and undiscovered) in the onshore area between Badami on the west and the Staines River on the east.

6.9.2.2 Summary of Direct and Indirect Effects

For a detailed discussion of the potential direct and indirect effects of the Project on cultural resources, see Section 4.3.2. The principal effects can be summed up as disturbance, artifact removal, or destruction of cultural resource sites, both identified and undiscovered, in the ROI. Sources of direct effects include ground-disturbing activities (primarily construction) while indirect effects include site destruction or disturbance from unauthorized site visitation, increased pedestrian traffic, looting, or contamination of cultural resources sites. Oil spills and their associated responses may pose sources of both direct and indirect effects.

6.9.2.3 Cumulative Effects on Cultural Resources

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 that can be taken to protect those sites which have been identified, undiscovered sites are susceptible to adverse effect in direct correlation to the number of construction activities and people in the region. There are a number of factors that lead to increased human activity in the eastern North Slope, including local village population increases; increased personnel related to oil and gas exploration and development; increased scientific research and survey; and increased tourism, including sport fishing and hunting. The cumulative direct effect of oil spills on cultural resources is expected to be minor. The subsequent cleanup (indirect cumulative effects) may result in minor adverse effects on archaeological resources.

6.9.2.4 Conclusions on Cultural Resources

Given the cultural resource management policies in place on the North Slope by the NSB, the State of Alaska, and various federal agencies, and the ability to mitigate potential adverse effects (including pre-construction site surveys) once cultural sites have been discovered, the cumulative effect to area cultural resources is expected to be minor.

6.9.3 Subsistence and Traditional Land Use

The key factors in the potential cumulative effects analysis for subsistence issues are the same as discussed in 4.3.3 and specified by Alaska National Interest Lands Conservation Act (ANILCA). These factors comprise three main categories – changes on the abundance and distribution of subsistence resources, changes in subsistence user access to resources, and changes in the competition for subsistence resources resulting from the Project.

6.9.3.1 Region of Influence

Changes in Abundance and Distribution of Subsistence Resources

For most subsistence resources, for direct and indirect effects analysis, the ROI will be primarily the Project area and subsistence use areas immediately adjacent to the project area. However, because most subsistence resources are migratory and during their annual cycles occupy areas many times larger than the project area, the ROI for cumulative effects expands to the entire range of potentially affected species. For the Bering-Beaufort-Chukchi Sea stock of bowhead whales, this includes the Beaufort Sea from the Canadian summer feeding grounds west to

Barrow and then the Chukchi Sea south to the Bering Seas and north to northern Siberia (and the eastern Siberian Sea). For other marine mammals the ROI for cumulative effects is less well known, but is probably more localized. For caribou, the ROI for cumulative effects is the entire range of the various caribou herds that use the area. For fish the ROI for cumulative effects for whitefish is at least from the MacKenzie River in Canada to the Colville River in Alaska, and for salmon conceivably much larger.

Changes in Subsistence User Access to Subsistence Resources

For most subsistence resources, for direct and indirect effects analysis, the ROI will be primarily the Project area and subsistence use areas immediately adjacent to the Project area. For bowhead whales and other marine mammals, the ROI will be expanded to include the documented use area for these species for the hunters of Kaktovik and Nuiqsut, the two communities closest to the Project area. For cumulative effects analysis, where potential population effects are possible, the ROI will extend to the full range of the potentially affected species (bowhead whales and other marine mammals, caribou, and fish). Bowhead whales are the species for which cumulative effects analysis are perhaps most critical.

Changes in the Competition for Subsistence Resources

The ROI for all subsistence resources for all potential effects in this category will be the Project area and those subsistence use areas immediately adjacent to the Project area.

6.9.3.2 Summary of Direct and Indirect Effects

For a detailed discussion of the potential direct and indirect effects of the Project on subsistence and traditional land use, see Section 4.3.3. The principal effects can be summed up as follows:

- Disruption to subsistence use of marine resources, including access to and distribution of whales and seals, and terrestrial resources. These potential effects are likely to be none to minor.
- Disruption to subsistence use of caribou through effects on caribou migration. While such potential effects, if unmitigated, could be major, the Project has been designed with features to minimize potential effects (elevated pipelines, scheduling of traffic to avoid migration periods, regular consultation process with local stakeholders) and such potential effects should be minor.
- Disruption to subsistence use of caribou (and associated uses of other subsistence resources) in the Brownlow Point locale. If the Project were to result in the abandonment of the Brownlow Point locale for the harvest of caribou (and other associated subsistence activities) the effect would be moderate. However, the Project has been designed with appropriate mitigation measures (as above) so that such potential effects should be minor.
- Disruption, contamination, or mortality of subsistence resources because of oil spills and accumulation of contaminants. These effects, as potential direct and indirect effects of the Project, should be none to minor.

See also Section 6.8, Biological Environment, for additional discussion of Project effects on important subsistence resources.

6.9.3.3 Cumulative Effects on Subsistence and Traditional Land Use

The contribution of the Project to the cumulative loss of habitat for subsistence resources and access because of construction and development is anticipated to present a minor adverse effect. The Project lands directly in question are not relied upon for much terrestrial subsistence use. Major construction occurs in the winter and local traffic is expected to be low. The separation between new roads and pipelines and elevation of new aboveground pipelines, pipeline wall thickness and location to reduce potential bullet strike damage during hunting, and consultation with subsistence hunters should mitigate cumulative effects. See also Section 6.8 of this ER for additional discussion about past and potential future effects to a number of important subsistence resources, including fish, birds, marine mammals, and terrestrial mammals (e.g., caribou, moose).

There are several categories of potentially harmful cumulative effects of reasonably foreseeable oil and gas development projects on marine resources used for subsistence. The Project will directly contribute only in a small incremental way to two of these. First, the Project will increase the marine vessel traffic traveling along the coast and coming into the Prudhoe Bay Dock and shallow-draft barges coming to the Point Thomson facility. Second, increased noise and activity onshore at the Project site may cause disturbance to marine and terrestrial mammals and subsistence users. These two sources could add to the existing marine traffic, current or planned offshore exploratory oil and gas activities, and future offshore oil and gas development and production activities. Cumulatively, these may have major effects on bowhead whales and whale migration patterns (and other marine mammals). The bowhead whale is of paramount cultural and nutritional value to the North Slope Iñupiat. Any action interfering with or altering the whales' migration pattern, particularly by driving them further offshore, could be detrimental. Altered whale migration patterns could have economic and safety implications for subsistence whalers, and could reduce their harvest success. Whalers could incur the additional expense of traveling further from their traditional whaling areas and could face higher safety risks because of the increased offshore distance traveled.

The Project incorporates mitigation measures to minimize project-related vessel traffic during the fall whale hunt, to route any required barge transport during this period inside the barrier islands, and to establish a process of frequent and easy communication between ExxonMobil operations and local subsistence users. The Project is thus expected to contribute only in a minor way to cumulative effects on bowhead whales and other marine mammals. Vessel traffic may have localized effect on seals, but the Point Thomson coastline is not often used for subsistence sealing. The cumulative effect of the Project and other external factors on subsistence use of marine resources is thus likely to be none to minor.

Disrupting the use of terrestrial subsistence resources is also a potential effect, with the primary concern being effects on caribou and caribou subsistence harvest. Concerns include loss of habitat, activities that would disturb animals and affect their availability for subsistence harvest (including diversion or changing of migration routes by pipelines), and restrictions on the access to hunting areas (either because of physical changes or the perception that the area is no longer suitable or desirable for subsistence hunting). The direct and indirect effects of the Project have been judged to be minor, given the incorporation of appropriate mitigation measures into the Project. The evaluation of cumulative effects is more speculative, given the lack of other oil and gas development in the Point Thomson area. If a pipeline for delivery of Point Thomson gas to "outside" markets should be built, with or without the development of offshore oil and gas resources, the likelihood of disruption of caribou migration patterns and subsistence caribou harvest could increase depending on the route and construction mode of the pipeline. Without knowing the design and route of such a pipeline, the evaluation of the potential cumulative effect of such a pipeline is difficult. Assuming that such a pipeline will incorporate the best available mitigation measures, the effect is likely to be minor to moderate.

Competition for subsistence resources is a concern of NSB residents, and there is potential for additive cumulative effect when accounting for increased staff employed at Point Thomson, as well as other oil and gas projects. However, this contribution of the Project would be none to minor because oil field workers are not allowed to hunt while on the job on North Slope; they would have to first return to their residences elsewhere before returning to hunt on the North Slope on their own time.

Oil spills causing mortality or contamination (tainting) of subsistence resources is a potential effect (Ahmaogak 1985, 1989; Albert 1990), which is amplified by additional oil and gas developments, especially offshore, in the region. The effect related to clean-up of an oil spill in any of these facilities would most likely be of short-term duration, but depending on the range and direction of effect could still be major to local populations of animals and subsistence users. The effects of oil spills on bowhead whales have not been extensively studied (Albert 1981; Hansen 1985). If such effects (including avoidance of the area, fouling of baleen, and real or perceived contamination) were biologically significant in terms of the bowhead whale population, all communities that harvest bowhead whales would be potentially affected. Subsistence uses might also be adversely affected by local perception of contamination, even if the actual effects were harmless or dissipated. Actual and perceived contamination of subsistence resources and related subsistence effects, regardless of the size of a spill, could be long-term (Impact Assessment Inc. [IAI] 2001; ADF&G 1995). The risk of occurrence of a spill is statistically increased by further oil and gas development in the region. However, the incremental contribution of the proposed Point Thomson development is none to minor given its location onshore and low probability of a spill reaching the marine environment. The Project may make an indirect contribution to these potential cumulative effects if its existence promotes or encourages the construction of a natural gas pipeline to outside markets, which in turn promotes or enables offshore oil and gas exploration and development that would otherwise not have taken place. Such effects are highly speculative in nature, however, and very difficult to evaluate.

See also Section 6.8 of this ER for additional discussion about potential cumulative effects of oil spills to a number of important subsistence resources, including fish, birds, marine mammals, and terrestrial mammals.

6.9.3.4 Conclusions on Subsistence and Traditional Land Use

For most subsistence resources, the Project will contribute only a minor incremental amount to overall cumulative effects. The same is true for the use of subsistence resources, except perhaps for caribou. The direct and indirect effects of the Project on caribou have been judged to be minor, given the incorporation of appropriate mitigation measures into the project. The evaluation of cumulative effects is more speculative, given the lack of other oil and gas development in the Point Thomson area. If a pipeline for delivery of Point Thomson gas to "outside" markets should be built, with or without the development of offshore oil and gas resources, the likelihood of disruption of caribou migration patterns and subsistence caribou harvest could increase, depending on the route and construction mode of the pipeline. Without knowing the design and route of such a pipeline, it is difficult to evaluate the potential cumulative effect of such a pipeline. Assuming that such a pipeline will incorporate the best available mitigation measures, the effect is likely to be minor to moderate. How much of this potential effect can be attributed to the Project is not at all clear – but further development of Point Thomson natural gas resources is probably a necessary enabling factor for the construction of a large gas pipeline.

6.9.4 Land Use and Ownership

6.9.4.1 Region of Influence

The ROI for land use encompasses lands and nearshore waters in the eastern half of the NSB, encompassing existing potential oil and gas development between Barrow and the U.S.-Canada border. It includes the two closest communities of Kaktovik and Nuiqsut, and the extent of the traditional subsistence lands and waters used by both communities. This ROI captures the Project's contribution to potential cumulative effects on land ownership, use, and management.

6.9.4.2 Summary of Direct and Indirect Effects

Land Ownership

As summarized in Section 4.3.8, the potential direct effects on land ownership, use, and management range from minor to moderate. These effects include changes in ownership associated with issuance and modification of state oil and gas leases and pipeline rights-of-way, primarily during construction and operation. There are no direct or indirect ownership effects on federal, Borough, and Alaska Native Corporation lands, or on Native allotments.

Land Use

Regarding land use, the Project represents a continuation and expansion of oil and gas land uses that have occurred, both intermittently in the Point Thomson area, and on North Slope over the last three decades. It also has a moderate potential to effect subsistence and other traditional uses during construction activities in the summer, and from the presence of industrial facilities in coastal areas used for subsistence. Project construction and operation activities also have a moderate potential to indirectly affect tourism and recreation use in the adjacent Refuge.

Land Management

Project drilling, construction, and operations will take place on state lands, and must comply with state land management regulations and plans, including the Alaska Coastal Management Program (ACMP). Project activities and operations must also comply with NSB Land Management Regulations and Coastal Management Plan. Indirectly, Project construction and operations may affect management of lands, resources, and activities within the Refuge, and consultation with the USFWS is recommended to mitigate potential adverse effects.

6.9.4.3 Cumulative Effects on Land Ownership, Use, and Management

Past and present actions and/or events that have affected the land ownership, use, and management include historic ongoing oil exploration and development, establishment of the Refuge, subsistence and traditional cultural uses of Borough lands and waters, and recreation and tourism by outside residents. Historic and current oil and gas activities on state and federal lands and waters have resulted in land ownership changes associated with issuance of leases and rights-of-way. These past and present activities have resulted in the spatial extension of oil and gas land and water use from the eastern portion of NPR-A to Point Thomson and federal offshore waters east of Prudhoe Bay.

North Slope residents, primarily from Kaktovik and Nuiqsut, have used lands and waters in the ROI for subsistence and other traditional cultural activities. Annual patterns and use of specific areas may vary due to the availability of fish and wildlife, but the area in general has been used continuously for many generations.

Recreation and tourism activities by outside residents within the ROI have been generally increasing, and are concentrated along river drainages within and outside the Refuge. Cruise ship and adventure tour activities have also been increasing in nearshore and offshore waters. All of these non-resident uses occur during the summer season.

RFFAs that contribute to cumulative effects on land ownership, use, and management include oil and gas developments onshore and offshore exploration activities within the North Slope, continuing recreation and tourism, and related marine and air traffic that would result from both ventures. Subsistence and traditional cultural land uses can be expected to continue in the ROI. Of particular note are potential sales gas pipelines from Point Thomson to Prudhoe Bay and Prudhoe Bay to the lower 48, offshore seismic and exploratory drilling activities associated with Camden Bay Hammerhead and Sivulliq prospects, and marine vessel traffic during the summer season in the area between Prudhoe Bay and Kaktovik. They represent a cumulative increase in oil and gas land use in the ROI.

These actions have potential onshore and offshore effects, which may affect subsistence and other traditional land uses, and tourism and recreation use in the area. Onshore developments may include increased roads, pipelines, and facility footprints; and increased aircraft and vehicle activity. Offshore developments may include additional coastal barge facilities and an increase in marine traffic supporting these development sites. The expansion of industrial activities into areas used for subsistence has in the past led to reduced subsistence and traditional use of some areas based on discomfort in using the affected areas.

Cumulatively, the Project contributes to a number of RFFAs that fit within the related categories of oil and gas exploration and development. The potential effects of extending oil and gas land use on the North Slope, and potential cumulative effects on subsistence and traditional uses, and adjacent recreation and tourism uses in the Refuge, could result in minor to moderate Project contributions to cumulative effects, depending on mitigation measures employed. This is partially offset by Project configuration intended to accommodate future Point Thomson and gas sale pipeline development, using existing pads and pipeline VSMs with minimal additional gravel footprint. For additional details on potential cumulative effects on subsistence and recreation tourism land uses, see Sections 6.9.3 and 6.9.6.

6.9.4.4 Conclusions on Land Ownership, Use, and Management

Development of the Project could result in minor contributions to cumulative changes in land ownership, since state lands and waters in the Mid-Beaufort area are classified for resource development. However, it would extend the eastern edge of oil and gas infrastructure and land use connected to Prudhoe Bay to the approximately one mile from western border of the Refuge. Along with potential activities at Badami and offshore exploration activities in Camden Bay, the Project will contribute to potential adverse cumulative effects on subsistence and traditional land uses. It will also contribute to potential adverse cumulative effects on recreation and tourism activities within the ROI, notably the western portion of the Refuge. However, timing of project construction activities, export pipeline wall thickness, and consultation with the community of Kaktovik to assure hunting in the Project area will mitigate contributions to cumulative effects. Timing of construction activities, other mitigation measures, and consultation with the Refuge will mitigate cumulative effects on recreation and tourism to some degree.

6.9.5 Transportation

Potential cumulative effects are caused by increased traffic in marine, air, and land transportation (permanent gravel roads and seasonal ice roads).

6.9.5.1 Region of Influence

The Region of Influence for transportation includes the area from Prudhoe Bay to the U.S.-Canada border, and the Dalton Highway. This includes land, air, and marine modes of transportation.

6.9.5.2 Summary of Direct and Indirect Effects

Traffic from the Project would directly affect the current transportation systems by increasing the number of vehicles using the three main forms of transportation used:

- Highway (traffic on the Dalton Highway, Deadhorse gravel road system, winter ice roads);
- air (fixed wing and helicopter traffic between Deadhorse and Point Thomson); and
- marine (coastal barge traffic between West Dock and Point Thomson, sealift traffic between lower 48 ports and Point Thomson).

This increase would be minor because the proposed number of vehicles/aircraft/vessels is not going to increase the current numbers considerably, with the exception of a moderate but short-term increase in barge traffic during construction and drilling operations.

6.9.5.3 Cumulative Effects on Transportation

Past projects in the area have generated traffic that has required building and expansion of roads, airstrips, and docks so that the projects are able to transport required materials to their sites. They have generated a large amount of Dalton Highway truck traffic, coastal, and marine barge traffic, and fixed wing and helicopter traffic. Past external actions in the area include oil and gas exploration, development of oil and gas production pads, and drilling in the Badami Development and Point Thomson areas.

Present and reasonably foreseeable future external actions that will potentially contribute to additional traffic, degradation of transportation facilities, and dust propagation are oil and gas developments in the Badami Development, Prudhoe Bay, the Colville River, and the Kuparuk River, oil and gas exploration in the vicinity of Beechey Point (between the Prudhoe Bay and Milne Point oil fields), Point Thomson, as well as other future undiscovered prospects. Projects operating currently and projects in the reasonably foreseeable future will cause added pressure to all of the transportation systems. See Table 6-2 for a list of past and present projects in the area of the Project.

With regard to road transportation systems, effects of these projects include dust accumulation along gravel roads and degradation of the road surface. Current and future projects in the area will cumulatively add to this, requiring more repair and maintenance of the road systems. Oil fields currently operating on the North Slope (such as Prudhoe Bay, Badami, Endicott, and Kuparuk) have been generating traffic on the Dalton Highway and are the main contributor to the traffic seen on the highway. Currently there is Annual Average Daily Traffic (AADT) of 290 vehicles per day from the Elliot Highway, starting on the Dalton Highway. This number drops down to 190 vehicles per day at the end of the Dalton Highway, because of tourists turning around south of the oil field facilities. Trucks bound for these oil fields use the Dalton Highway regularly to carry heavy loads to their respective camps. The heavy loads driven on this gravel road cause potholing and high maintenance activity, as well as spraying dust and gravel up to about 30 feet off the highway and pads creating a dust shadow up to 150 feet or more (BLM 2008). In the winter months, the potential effects on the Dalton Highway are considerably less because of frozen conditions and snow minimizing dust. During Project construction the number of trucks used to transport materials to the site would increase traffic volume by 0.3 percent, and volumes would taper off as the Project is completed. This increase in traffic could also occur at the same time as other construction projects in the area, but would not create a major problem requiring any changes to the current road system, as the road is operating far below full capacity.

Air transportation is normally used to transport workers to the oil fields, both to Deadhorse, and between Deadhorse and other fields not connected to the road system. Construction of the Project would cause a rise in the number of flights in and out of the North Slope area, but is a relatively small increase. Present flights to the Kaktovik airstrip would not likely be affected as there are only three flights per day in and out of Kaktovik (Barter Island). The number of flights to Point Thomson would decline after the construction period and become steady as the regular operation of the site is under way. Cumulative effects should not adversely affect the current aviation schedules, as the Project would create a rise of 4 percent in air traffic. Similar effects from other future project would be expected and the total would be a minor change in capacity. The effects would be most evident during construction of the Project. If it occurred simultaneously with other construction projects, this could directly affect the existing air transportation system, causing short-term congestion during the duration of construction.

Barge transportation on the North Slope would also be adversely affected during the construction of the Project, as an increase in smaller barges traveling in and out of Prudhoe Bay could potentially cause short-term congestion for the extent of the barge season. Barge traffic can also expect to be associated with RFFAs, such as Eastern Beaufort OCS exploration activities, and construction of a Point Thomson sales gas pipeline. The barge traffic would cease during the winter as materials are trucked up the Dalton Highway, the Spur Road, and ice roads. Once the Project is in operation, barge traffic levels would likely decrease.

6.9.5.4 Conclusions on Transportation

Construction and operation of the Project could result in minor contributions to regional road, marine, and air traffic in the region, and specifically the area east of Prudhoe Bay. Such contributions would be most evident during the Project construction period when marine and air traffic activities would be occurring, and short-term congestion could occur. However, because much of the pipeline and facility activities would occur during the winter, there would not be overlap with marine activities and air support for offshore drilling and seismic operations.

6.9.6 Recreation

6.9.6.1 Region of Influence

The extent to which the Project would contribute to cumulative effects on recreation is spatially constrained to the area where activities related to the Project (such as transportation, construction, and operations) would overlap with and affect recreational use. The ROI for cumulative effects on recreation is defined as the North Slope of Alaska from Barrow to Kaktovik.

6.9.6.2 Summary of Direct and Indirect Effects

The Project would not directly impede any currently-practiced recreation activities. It would result in some level of visual and aural disruptions/disturbances associated with drilling and the construction and operation of an industrial facility, which would affect the recreation setting and experiences along the Canning River and other adjacent portions of the Refuge, and elsewhere in the Point Thomson area. Other indirect effects include potential aural disturbance to wilderness values due to increased numbers of flights to and from the Point Thomson area. Some of these effects would be ameliorated by the fact that most recreation activities occur during the summer. Aural disturbances from drilling would mainly be restricted to winter and visual distractions from flares and facility lighting are likely to be minor, given the long Arctic sunlight in summer.

Activities associated with the Project have the potential to result in a noticeable change in the recreation setting and experience that would persist more than two years and extend beyond the Project area. Consequently, potential effects to recreation that may result from the Project are expected to be moderate during construction and minor to moderate during operations. For a detailed discussion of the potential direct and indirect effects of the Project on recreation, see Section 4.3.6. Effects to recreation are primarily related to visual aesthetics and noise. These subjects are discussed in more detail in sections 4.3.6 and 4.3.7, respectively.

6.9.6.3 Cumulative Effects on Recreation

Since the discovery of Prudhoe Bay in 1968, activities associated with oil and gas exploration, development, and transportation have been and continue to be the main sources of change to recreation resources on the North Slope of Alaska. The principal destination for tourism and recreation within the ROI is the Refuge, where most visitors float the rivers, including the Canning River. Existing oil development on the North Slope is not visible from the Refuge and does not typically affect its recreation setting. There are some infringements on solitude that result from the sights and sounds of aircraft or industrial activities (such as offshore seismic exploration and drilling, and current Point Thomson activities) but they are generally transient.

Unlike prior North Slope development, the Project is within sight and hearing distance of a portion of the Canning River and the Refuge, and development of the Project could contribute to cumulative effects that have a longer duration that exploratory drilling activities. Other potential future oil and gas development in the vicinity of the Project, such as of sales gas pipeline for Point Thomson to Prudhoe Bay, could also affect recreation access to the area, opportunities for solitude, and the vast natural landscapes.

6.9.6.4 Conclusions on Recreation

Recreational opportunities sought out in and near the Project area are inextricably tied to the natural state of the North Slope of Alaska including the Refuge, and Mollie Beattie Wilderness. Incremental human development and industry alters the perceived character of this expansive area of vast natural landscapes and solitude. Visitors recreating within the Refuge may encounter the sights and sounds of nearby industrial development as a result of the Project and other past, present, and RFFAs. These actions do not and would not preclude currently practiced recreational activities, though they could have a minor to moderate adverse affect in some locations.

6.9.7 Visual Aesthetics

6.9.7.1 Region of Influence

The ROI for visual resources includes area from the Endicott Facility due east of Prudhoe Bay, east to the Canning River, north to the Barrier Islands, and south to the southern boundary of the Project area. Potential effects that may result from natural events (such as weather and coastal erosion) are not considered in this cumulative effects analysis because the visual qualities of the ROI relate primarily to its perceived natural state, which is shaped by these events.

6.9.7.2 Summary of Direct and Indirect Effects

Key Project actions that may affect visual resources include introduction of new lines and visual contrasts from construction and operation of structures, pipeline access roads, ice roads, and the airstrip; increased light and glare emanating from the facility and airstrip; and increased air, land, and marine activity. These actions would result in noticeable changes in the appearance of the landscape within the ROI that would be visible by sensitive viewer groups (Alaska Native communities and recreational visitors to the Refuge and other areas near the Project) for the duration of the Project. Consequently, effects to visual resources that may result from the Project are expected to be moderate.

6.9.7.3 Cumulative Effects on Visual Aesthetics

Past actions that could affect visual resources within the ROI include military operations at Bullen Point and oil and gas exploration and development within the study area. Visual effects that result from military operations generally include increased air and marine activity. Past and present oil and gas exploration activity within the ROI are listed in Table 6-2. Effects to visual resources resulting from these actions are similar to those described for the Project. Effects are generally localized but have resulted in a noticeable change to the landscape. RFFAs within the ROI are limited to on- and offshore oil and gas exploration, development, and transportation, and seismic exploration (Table 6-2). Individually, these actions would introduce contrasting elements and new lines to inland and marine landscapes and lighting visible in the nighttime skyline. They would also increase activity in air, land, and marine environments. Cumulative effects would include noticeable changes in nighttime views from vantage points in the Refuge and nearby Sadlerochit Mountains. Views from the nearshore environment within the barrier islands would also be noticeably altered. These effects must be considered with the caveat that they would be localized and only between several hundred and a few thousand sensitive receptors would be affected on an annual basis.

Cumulative effects from the Project, construction of a Point Thomson gas sales pipeline, and exploration activities during the summer in Camden Bay are expected to occur at an intensity, duration, and extent that would substantially alter the appearance of the regional landscape, and visibility to recreation users in the Refuge, for periods that extend beyond two years. The Project will have a moderate contribution to cumulative effects.

6.9.7.4 Conclusions on Visual Aesthetics

Cumulative effects to visual resources resulting from implementation of the Project and other past, present, and RFFAs within the ROI could be moderate. Sensitive receptors, including recreators and Alaska Native people, would experience noticeable but fairly localized long-term changes to visual resources. Adverse effects would result from introduction of new lines and visual contrasts as well as increased light and glare from construction, operation, and maintenance of facilities and associated infrastructure. Activity in the air, on land, and in the marine environment would also increase.

6.9.8 ENVIRONMENTAL JUSTICE

6.9.8.1 Region of Influence

The ROI for environmental justice encompasses the entire NSB, particularly the two closest communities of Kaktovik and Nuiqsut, their traditional subsistence lands and waters (see Figures 3-32, 3-33, 3-40, and 3-41), and related community ties to Anaktuvuk Pass. This ROI captures potential cumulative effects of the Project on employment and income, public revenue, subsistence, and aspects of Iñupiat culture, health, and safety.

6.9.8.2 Summary of Direct and Indirect Effects

As summarized in Section 4.3.8, the potential direct effects on employment, subsistence, aspects of Iñupiat culture, health, and safety range from minor to moderate, with some beneficial effects on safety (improved number of response vessels), employment, revenue (increased tax base), services and infrastructure. Throughout the drilling and construction phases, indirect effects range from none to minor. The operations phase may result in moderate positive effects due to increased employment opportunities and increased tax base, which fund public services and contribute to the quality of life in local communities.

6.9.8.3 Cumulative Effects on Environmental Justice

Past and present actions and/or events that have affected the NSB and its communities include transportation, ongoing oil exploration and development, and recreation and tourism by outside residents. These past and current activities affect the current status of employment, subsistence, cultural aspects of Iñupiat culture, health, and safety of local residents.

Employment. Job training and diversification in Alaska Native corporation subsidiaries has placed local residents in temporary and permanent positions within the oil and gas development world of contracting and support services. These positions provide income to residents that is shared in local communities. Development of oil and gas facilities contributes to the Borough and state tax base and revenue for local communities for public services. To some, this employment presents conflicts with subsistence scheduling. Trying to balance traditional Iñupiat community values with individualistic nature of work in the oil and gas industry may create a sense of place conflict for some. However, jobs also provide income used to purchase shared resources used in communal subsistence activities. Local communities, such as Kaktovik host base camps for outfitters who take tourists through the Refuge.

Subsistence. As summarized in Section 6.9.3, direct and indirect subsistence effects from the Project are anticipated to be minor. Oil and gas exploration and development activities could affect availability for harvest of portions of the PH and CAH caribou, and bowhead whales. Increased marine and air traffic in the region, and effects of development on portions of the CAH and PH movements and distribution, and perceived adverse effects on harvest has been raised as a concern by the NSB and some communities.

Cultural Aspects. Access to traditional use sites, camps, and cemeteries in the Project area currently remains unimpeded. Through close coordination with residents and NSB Iñupiat History, Language, and Culture Division of the North Slope Borough (IHLC), access to remote sites used for traditional activities and recreation will be unaffected.

Social Organization and Well-Being. "Effects on social organization" involve much more pervasive potential socioeconomic effects. These can include how people group themselves for specific activities, general patterns or norms of behavior, or culturally valued and iconic behaviors such as language use. Continued voluntary initiatives like the ones in place for this Project with the Alaska Eskimo Whaling Commission and Kaktovik whaling captains (restrictions on barging during whaling) may serve to help offset any potential for effects on social organization (whaling crew integrity directly; sharing within and between communities less directly, for example). This is a specific example of mitigation supplementing an annual CAA, which provides a communication/consultation process and procedures between oil industry marine users and subsistence whalers to avoid potential disturbance to subsistence whaling activities from oil industry marine traffic.

A health impact assessment, coordinated by the State of Alaska, will be conducted during the permitting process for the Project to address community and individual well-being issues (drug and alcohol use, domestic crimes, and other issues). These topics will not be developed in this document, but are listed below as a separate category of concern.

Health and Safety. Local residents have long voiced concerns regarding potential effects from pollutant discharge and emissions, and potential adverse effects on human health and accumulation of pollutants in the subsistence food chain. Current oil and gas project sites and related traffic have mitigated this potential through BMPs, spill risk analysis, response plans, efficient traffic routing (e.g., marine, air, and roads), drills, and open communication with residents and subsistence representatives.

Reasonably foreseeable developments include oil and gas developments onshore and offshore exploration activities within the North Slope, increased recreation and tourism, and related marine and air traffic that would result from both ventures. These actions have potential onshore and offshore effects which may affect subsistence whaling, subsistence hunting, cultural values (sense of place), employment opportunities, and funding of NSB services and capital projects in communities. Onshore developments may include increased roads, pipelines, and facility footprints; and increased aircraft and vehicle activity. Offshore developments may include additional barging and an increase in marine traffic supporting these development sites. These RFFAs and related effects are addressed under Sections 6.2.5. 6.2.6, 6.2.7, 6.3.3, 6.3.6, and 6.3.7. An increase in marine traffic does have the benefit of providing for increased emergency response for marine users. Whereas environmental justice is not the only resource of concern, this potential for cumulative effect of RFFAs on local NSB communities is moderate, both beneficial and adverse.

6.9.8.4 Conclusions on Environmental Justice

Cumulatively, the Project contributes to a number of RFFAs that fit within the related categories of oil and gas exploration and development. The potential effects on terrestrial resources, marine mammals, subsistence, aspects of Iñupiat culture, air and water quality, employment opportunities, and NSB revenue of each of these projects may range from minor to moderate, depending on the projects' size, timing, and mitigation. Cumulatively, this Project's potential contribution to the current status of resources may range from minor to moderate. As such, it is difficult to quantify effects on aspects of Iñupiat culture, community and resident connection to the land.

Potential adverse effects to consider may be due to:

- the visual aspect of the project site;
- the potential of pollutants and emissions;
- the disturbance of marine and terrestrial mammals migration routes;
- real or perceived limitations on access to traditional activities;
- the concern of contaminants in the food chain; and
- the potential loss in traditional values due to outside influences.

Potential beneficial effects are moderate and are as follows:

- increased employment and income opportunities;

- increased tax base resulting in more revenue for public services;
- increased assets available to respond to emergencies;
- addition of community cultural support (such as museums and archaeological preservation); and
- increased support for area non-profits, educational initiatives, and scholarships.

7.0 BIBLIOGRAPHY

40 CFR 1508.7. (2008). Chapter V, Council on Environmental Quality; part 1508, Terminology and Index. Sec. 1508.7 Cumulative impact. Title 40, Volume 31, Code of Federal Regulations. p.1136.

40 CFR 1508.8. (2008). Chapter V, Council on Environmental Quality; part 1508, Terminology and Index. Sec. 1508.8 Effects. Title 40, Volume 31, Code of Federal Regulations. p.1136.

40 CFR 1508.27. (2008). Chapter V--Council on Environmental Quality; part 1508, Terminology and Index. Sec. 1508.27 Significantly. Title 40, Volume 31, Code of Federal Regulations. p.1139.

59 FR 50796. (1994). Endangered and threatened wildlife and plants: Removal of Arctic peregrine falcon from the list of threatened and endangered wildlife. Title 50, Code of Federal Regulations, Part 17, 1993 (Ed.) (50 CFR 17). Federal Register Vol. 59, No. 192, pp. 50796-50805.

61 FR 26771. (1996). Executive Order 13007 of May 24, 1996: Indian sacred sites. Federal Register Vol. 61 No. 104 p. 26771.

71 FR 43926. (2006). Letters of authorization to take marine mammals. U.S. Department of the Interior, Fish and Wildlife Service. 28 December 2006. Federal Register Vol. 71, No. 249, p. 78220.

71 FR 43925. (2006). Marine Mammals; Incidental take during specified activities; final rule. Title 50, Code of Federal Regulations, Part 18. (50 CFR 18). 50 CFR Part 18 Federal Register Vol. 71, No.148, p. 28265.

73 FR 28265. (2008). Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. Title 50, Code of Federal Regulations, Part 17. (50 CFR 17). Federal Register Vol. 73, No. 95, p. 28265.

73 FR 28280. (2008). Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. Title 50, Code of Federal Regulations, Part 17. (50 CFR 17). Federal Register Vol. 73, No. 95, p. 28280.

73 FR 28281. (2008). Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. Title 50, Code of Federal Regulations, Part 17. (50 CFR 17). Federal Register Vol. 73, No. 95, p. 28281.

73 FR 28288. (2008). Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. Title 50, Code of Federal Regulations, Part 17. (50 CFR 17). Federal Register Vol. 73, No. 95, p. 28288.

73 FR 28292. (2008). Endangered and threatened wildlife and plants; determination of threatened status for the polar bear (*Ursus maritimus*) throughout its range. Title 50, Code of Federal Regulations, Part 17. (50 CFR 17). Federal Register Vol. 73, No. 95, p. 28288.

73 FR 28212. (2008). Endangered species act listing of the polar bear, final rule. 15 May 2008. Federal Register Vol. 73, p. 28212.

73 FR 28946. (2009). Notice of marine mammal protection: Draft revised stock assessment reports for Pacific walrus, southern Beaufort Sea polar bear, and Chukchi/Bering Seas polar bear. Federal Register Vol. 74 No. 116, pp. 28946-28947.

Aars, J., N.J. Lunn, and A.E. Derocher (Eds.) (2006). Polar bears: Proceedings of the 14th working meeting of the IUCN/SSC polar bear specialist group, 20-24 June 2005, Seattle, Washington. IUCN, Gland, Switzerland, and Cambridge, UK.

ABR, Inc. Environmental Research & Services. (2007). Summary of research on yellow-billed loons breeding in an area of oil development. Unpublished report prepared for ConocoPhillips Alaska, Inc., and provided to the U.S. Fish and Wildlife Service during comment period for the 90-day finding of the yellow-billed loon.

Adams, A.B., and T.C. Cannon. (1987). Overwintering study. Vol. 7, Part V In: Endicott Environmental Monitoring Program, Final Reports, 1985. Report by Envirosphere Co. for Alaska District, U.S. Army Corps of Engineers, Anchorage, AK. pp. 33.

Adams, K.M. and H. Hernandez. (1977). Snow and ice roads: ability to support traffic and effects on vegetation. Arctic 30: 13-27.

Ahmaogak, G.N. (1986). Formulating U.S. Arctic research policy: Recommendations from the North Slope Borough. In: M.M.R. Freeman and C.W. Slaughter (Eds.). Arctic Science Policy and Development: Proceedings, a UNESCO-MAB International Conference, August 28-30, 1985, University of Alaska Fairbanks. Washington, DC: U.S. Man and the Biosphere Program.

Ahmaogak, G.N., Sr. (1985). Comments regarding the development of a policy pertaining to research in the U.S. Arctic. Inuit Studies 9 2: 27-32.

Ahmaogak, G.N. (1989). Protecting the habitat of the bowhead whale. Proceedings of the Sixth Conference of the Comite Arctique International, 13-15 May 1985. pp. 593-597. L. Rey and V. Alexander (Eds.). E.J. Brill, New York, NY. 637 pp.

Alaska Clean Seas (ACS). (2009). Alaska North Slope response. Alaska Clean Seas. Available online at: http://www.alaskacleanseas.org/corporate.htm. Accessed 22 September 2009.

Alaska Department of Environmental Conservation (ADEC). (2008). Summary report of improvements to the Alaska greenhouse gas emission inventory: draft. Alaska Department of Environmental Conservation.

ADEC. (2009a). Contaminated sites database. Available online at: http://dec.state.ak.us/spar/csp/search. Accessed 31 August 2009.

ADEC. (2009b). Spill sites database. Available online at: http://dec.state.ak.us/spar/perp/search. Accessed 31 August 2009.

ADF&G. (1995). An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska. Prepared for Minerals Management Service, Alaska OCS Environmental Studies Program, Technical Report 160.

Alaska Department of Fish and Game (ADF&G). (1998). State of Alaska species of special concern 1998. Available online at: http://www.adfg.state.ak.us/special/esa/species_concern.php. Accessed November 2009.

ADF&G. (2001). Caribou management report of survey-inventory activities 1 July 1998-30 June 2000. C. Healy, (Ed.), Project 3.0 Juneau, Alaska.

ADF&G. (2003). Caribou management report of survey-inventory activities 1 July 2000-30 June 2002. C. Healy, (Ed.), Juneau, Alaska.

ADF&G. (2006). Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Juneau, AK. Available online at: http://www.sf.adfg.state.ak.us/statewide/ngplan/index.cfm. Accessed November 2009.

ADF&G 2007 was cited incorrectly. Please see Harper 2007 for correct reference.

ADF&G. (ND). Available online at: http://www.subsistence.adfg.state.ak.us/CSIS. Accessed 17 November 2009.

Alaska Department of Labor (ADOL). (1999). Labor force statistics by month for North Slope Borough, 1990 to present. Available online at: http://www.labor.state.ak.us/research/emp_ue/nosllf.htm. Accessed 16 November 2009.

ADOL. (2008). Alaska's 2008 population, Alaska economic trends. Alaska Department of Labor. Available at http://labor.alaska.gov/research/trends/may09pop.pdf.

Alaska Department of Natural Resources (ADNR). (1978). Proposed Point Thomson oil and gas lease sale #29A, third hearing, Kaktovik, Alaska, July 27, 1978. Alaska Department of Natural Resources.

ADNR 1999 was incorrectly cited. Please disregard.

ADNR. (2001). Oil and gas lease sale, North Slope foothills areawide 2001, final finding of the Director.

ADNR. (2002). ADF&G Point Thomson Area stream fish sampling. 1-8 August 2002 Trip Report. Jack Winters and William Morris.

ADNR. (2007). Alaska oil & gas report. Alaska Department of Natural Resources, Division of Oil & Gas (for the period ending 31 December 2006). Available online at: http://dog.dnr.state.ak.us/oil/products/publications/annual/report.htm

ADNR. (2008). North Slope areawide oil and gas lease sale, final best interest finding. Anchorage, AK: Alaska Department of Natural Resources.

ADNR. (2009). Proposed Beaufort Sea areawide oil and gas lease sale: preliminary finding of the director and ACMP consistency analysis. Alaska Department of Natural Resources, Division of Oil and Gas.

Alaska Department of Revenue (ADOR). (2009). Alaska oil production. Alaska Department of Revenue. Available online at: http://tax.alaska.gov/programs/oil/production.aspx.

Alaska Department of Transportation and Public Facilities (ADOT&PF). (2009). Northern region annual traffic volume report 2006, 2007, 2008. Northern Region: ADOT.

Alaska Interstate Construction, LLC. (2002). Letter, results of water source investigations – Badami to Flaxman Island, Work Order No. C56423-2. Prepared for ExxonMobil Production Company. Anchorage, AK.

Alaska Natural Heritage Program (AKNHP). (2008). Vascular plant tracking list. Available online at: http://aknhp.uaa.alaska.edu/botany/pdfs/Rare%20PLant%20List%202008.pdf. Last modified April 2008. Accessed September 2009.

Alaska Natural Heritage Program (AKNHP). (2009). Birds tracking list, 2007. Anchorage, AK: University of Alaska. Available online at: http://aknhp.uaa.alaska.edu/zoology/Zoology_Tracking.htm. (Accessed November 2009).

Alaska Outdoors Supersite. (2009). Available online at: http://outdoorsdirectory.com/boating/arl/canning.htm. Accessed 24 September 2009.

Alaska Paleontological Database. (2009). Available online at: http://www.alaskafossil.org/. Accessed September 2009.

Alaska Shorebird Group (ASG). (2004). A conservation plan for Alaska shorebirds. Unpublished report, Alaska Shorebird Group, U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

ASG. (2008). Alaska shorebird conservation plan. Version II. Anchorage, AK: Alaska Shorebird Group, 2008. Available online at: http://alaska.fws.gov/mbsp/mbm/shorebirds/plans.htm Accessed November 2009.

Albert, T.F. (1981). Some thoughts regarding the possible effects of oil contamination on bowhead whales, *Balaena mysticetus*. In: Tissue structural studies and other investigations on the biology of endangered whales in the Beaufort Sea, T.F. Albert, (Ed.), Volume II. Anchorage, AK. USDOI, BLM.

Aldrich, J.W. (1981). A stochastic analysis of some existing ice thickness data. The Northern Engineer 13: 4-10.

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. S. Raymond and P. Schledermann, (Eds.). University of Calgary Archaeological Association. Calgary, Alberta. pp. 21-31.

Alexander, H. (1987). Putu: A fluted point site in Alaska. Publication No. 17. Department of Archaeology, Simon Frazer University, Burnaby, British Columbia.

Alexander, S.A., D.L. Dickson, and S.E. Westover. (1997). Spring migration of eiders and other waterbirds in offshore areas of the western arctic. In: Dickson, D.L. (Ed.) King and common eiders of the western Canadian arctic, Canadian Wildlife Service occasional paper No. 94 Edmonton, AB.

Alt, K.T., and D.R. Kogl. (1973). Notes on the whitefish of the Colville River, Alaska. Journal of the Fisheries Research Board of Canada 30: 554-556.

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. In: Cade, T.J., J. Henderson, C.G. Thelander, and C.M. White, (Eds.). Peregrine falcon populations, their management, and recovery. Boise, ID: The Peregrine Fund.

American Bird Conservancy and National Audubon Society (ABC and NAS). (2007). The United States watchlist of birds on conservation concern, 2007*.* Available online at: http://www.abcbirds.org/abcprograms/science/watchlist/index.html. Accessed November 2009.

American Ornithologists' Union (AOU). (1983). Check-list of North American birds. 7th Edition. American Ornitholigists's Union, Washington, D.C.

Amstrup, S.C. (1993) Human disturbances of denning polar bears in Alaska. Arctic 46: 246-250.

Amstrup, S.C. (1995). Movements, distribution, and population dynamics of polar bears in the Beaufort Sea, Ph.D. dissertation. Fairbanks, AK: University of Alaska.

Amstrup, S.C. (2000). Polar bear. In: J. C. Truett, J.C. and S. R. Johnson (Eds.) The natural history of an arctic oil field: development and the biota. San Diego, CA: Academic Press.

Amstrup, S.C. (2002). Polar bear, *Ursus maritimus*. In: D.C. Douglas, P.E. Renolds, and E.B. Rhode (Eds.). Arctic Refuge coastal plain terrestrial wildlife research summaries, biological science report USGS/BRD/BSR-2002-0001. U.S. Geological Survey, Biological Resources Division.

Amstrup, S.C. (2003a). Polar bear (*Ursus maritimus*). In: Feldhamer, G.A., B.C. Thompson, and J.A. Chapman (Eds.) Wild mammals of North America: biology, management, and conservation, 2nd ed. Baltimore, MD: Johns Hopkins University Press.

Amstrup, S.C. (2003b). Polar bear maternal den distribution in northern Alaska, unpublished report extracted from the Alaska Biological Science Center Polar Bear Research Database. Anchorage, AK: U.S. Geological Survey, Biological Resources Division.

Amstrup, S.C., B.G. Marcot, and D.C. Douglas. (2007). Forecasting the range-wide status of polar bears at selected times in the 21st Century, USGS Administrative Report.

Amstrup, S.C., C. Gardner, K.C. Myers, and F.W. Oehme. (1989). Ethylene glycol (Antifreeze) poisoning of a free-ranging polar bear. Veterinary and Human Toxicology: 317-319.

Amstrup, S.C., G. Durner, I. Stirling, N.J. Lunn, and F. Messier. (2000). Movements and distribution of polar bears in the Beaufort Sea. Canadian Journal of Zoology 78: 948-966.

Amstrup, S.C., G. York, T.L. McDonald, R. Nielson, and K. Simac. (2004). Detecting denning polar bears with forward-looking infrared (FLIR) imagery. BioScience 54: 337-344.

Amstrup, S.C., G.M. Durner, I. Stirling, and T.L. McDonald. (2005). Allocating harvests among polar bear stocks in the Beaufort Sea. Arctic 58: 247-259.

Amstrup, S.C., G.M. Durner, T.L. McDonald, and W.R. Johnson. (2006). Estimating potential effects of hypothetical oil spills on polar bears. U.S. Geological Survey report. Anchorage, AK: Alaska Science Center.

Amstrup, S.C., I. Stirling, and J.W. Lentfer. (1986). Past and present status of polar bears in Alaska. Wildlife Society Bulletin 14: 241-254.

Amstrup. S.C., and C.Gardner. (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*. In: J. W. Lentfer (Ed.) Selected marine mammals of Alaska: species accounts with research and management recommendations. Washington, DC: Marine Mammal Commission.

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 (ABR), Inc., Fairbanks, AK.

Anderson, B.A. (2009). Unpublished data. ABR, Inc. Fairbanks, AK.

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.

Anderson, B.A., A.A. Stickney, T. Obritschkewitsch, P.E. Seiser, and J.E. Shook. (2009). Avian studies in the Kuparuk Oilfield, Alaska, 2008. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Anderson, B.A., and B.A. Cooper. (1994). Distribution and abundance of spectacled eiders in the Kuparuk and Milne Point Oilfields, Alaska. Report for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK.

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.

Anderson, B.A., R.J. Ritchie, A.A. Stickney, J.E. Shook, J.P. Parrett, A.M. Wildman, and L.B. Attanas. (2003). Avian studies in the Kuparuk Oilfield, Alaska. Report for ConocoPhillips Alaska, Inc., and the Kuparuk River Unit, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

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.

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.

Anderson, D.D. (1968). A stone age campsite at the gateway to America. Scientific American 218.

Anderson, D.D. (1984). Prehistory of North Alaska. In: Damas, D. (Ed.) Handbook of North American Indians, Arctic (V). Washington, DC: Smithsonian Institution.

Andres, B.A. (1989). Littoral zone use by post-breeding shorebirds on the Colville River Delta, Alaska. Thesis, Ohio State University, Columbus, Ohio.

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.

Andrews, C.L. (1939). The Eskimo and his reindeer in Alaska. Caxton Printers.

Angliss, R.P. and K.L. Lodge. (2004). Alaska marine mammal stock assessments, 2004, NOAA technical memorandum NMFS-AFSC-133. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Angliss, R.P. and R.B. Outlaw. (2008). Alaska marine mammal stock assessments, 2007, NOAA technical memorandum NMFS-AFSC 180. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.

Arctic Environmental Information Data Center (AEIDC). (1974). Alaska regional profiles, Vol. II: Arctic Region. Anchorage, AK: University of Alaska.

Arnold, R.D. (1978). Alaska Native land claims. Anchorage, AK: Alaska Native Foundation.

Arthur, E.A and E. Lenart. (2003). Personal communication. Alaska Department of Fish and Game. Fairbanks, AK.

Arthur, S.M. (2001). Personal communication. Alaska Department of Fish and Game, Fairbanks, AK.

Arthur, S.M. and P.A. Del Vecchio. (2007). Effects of oil field development on calf production and survival in the Central Arctic Herd, interim research technical report, Project 3.46. Juneau, AK: Alaska Department of Fish and Game.

Arthur, S.M., K.R. Whitten, F.J. Mauer, and D. Cooley. (2003). Modeling the decline of the porcupine caribou herd, 1989-1998: the importance of survival vs. recruitment. Rangifer, Special Issue 14: 123-130.

ASR 1990 was incorrectly cited. Please see IAI 1990a for correct reference.

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 1: 218-235.

Babaluk, J.A., J.D. Reist, J.D. Johnson, and L. Johnson. (2000). First record of sockeye, *Oncorhynchus nerka,* and pink salmon, *O. gorbuscha,* from Banks Island and other records of Pacific salmon in Northwest Territories, Canada. Arctic 53 2: 161-164.

Babcock, C.A. (1986). Vegetation patterns and microtine rodent use of tundra habitats in northeastern Alaska. M.S. Thesis, Fairbanks, AK: University of Alaska.

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, AK.

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, AK.

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, AK.

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, AK.

Ballard, W.B., M.A. Cronin, M.D. Robards, and E.H. Follmann. (2000b). Body sizes, ages, reproductive status, and sex ratios of Arctic foxes, *Alopex lagopus*, in the Prudhoe Bay oil field, Alaska." Canadian Field-Naturalist 114: 493-494.

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.

Barnes, P.W. and E. Reimnitz. (1974). Sedimentary processes on arctic shelves off the northern coast of Alaska. pp. 439-476 In: The Coast and Shelf of the Beaufort Sea: Proceedings of a Symposium on Beaufort Sea Coast and Shelf Research, J.C. Reed and J.E. Sater, (Eds.), Arlington, VA: Arctic Institute of North America.

Barry, T.W., and R. Spencer. (1976). Wildlife response to oil well drilling. Canadian Wildlife Service Progress Notes No. 67.

Bascom, W. (1980). Waves and beaches: The dynamics of the ocean surface. Revised and updated. New York: Anchor Books, Doubleday.

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.

Becker, E.F., and P.X. Quang. (2009). A gamma-shaped detection function for line-transect surveys with mark-recapture and covariate data. Journal of Agricultural, Biological, and Environmental Statistics 14 2: 207-223.

Bee, J.W., and E.R. Hall. (1956). Mammals of northern Alaska on the Arctic Slope, miscellaneous publication No. 8. Museum of Natural History, University of Kansas.

Bendock, T.N. (1979). Inventory and cataloging of Arctic area waters. Alaska Department of Fish and Game, Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report 20: 1-64.

Bengtson, J.L., L.M. Hiruki-Raring, M.A. Simpkins, and P.L. Boveng. (2005). Ringed and Bearded Seals Densities in the Eastern Chukchi Sea, 1999-2000.Polar Biology 28 11: 833-845.

Beranek, L.L. (1988). Noise and vibration control, revised edition. Washington, DC: Institute of Noise Control Engineering.

Berezovskaya, S.L., J.E. Derry, D.L. Kane, R.E. Geick, M.R. Lilly, and D.M. White. (2007). Snow Survey Data for the Sagavanirktok River/Bullen Point Hydrology Study: Spring 2007, Report INE/WERC 07.18. Fairbanks, Alaska: University of Alaska Fairbanks, Water and Environmental Research Center.

Berezovskaya, S.L., J.E. Derry, D.L. Kane, R.E. Geick, M.R. Lilly, and D.M. White. (2008). Snow Survey Data for the Sagavanirktok River / Bullen Point Hydrology Study: Spring 2008, Report INE/WERC 08.15. Fairbanks, Alaska: University of Alaska Fairbanks, Water & Environmental Research Center.

Bergen, S., G.M. Durner, D.C. Douglas, and S.C. Amstrup. (2007). Predicting Movements of Female Polar Bears Between Summer Sea Ice Foraging Habitats and Terrestrial Denning Habitats of Alaska in the 21st Century: Proposed Methodology and Pilot Assessment, U.S. Geological Survey Administrative Report. Anchorage, AK: Alaska Science Center.

Berger, T.R. (1985). Village journey – The report of the Alaska Native Review Commission. New York: Hill and Wang.

Bergman, R.D. and, D.V Derksen. (1977). Observations on Arctic and red-throated loons at Storkersen Point, Alaska. Arctic 30: 41-51.

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, Resource Publication 129. Washington, DC: U.S. Department of Interior, Fish and Wildlife Service.

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.

Bethke, R., M.K. Taylor, S.C. Amstrup, and F. Messier. (1996). Population delineation of polar bears using satellite-collar data. Ecological Applications 6: 311-317.

Bickham, J.W., S.M. Carr, B.G. Hanks, D.W. Burton, and B.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.

Bilgin, A. (1975). Nutrient status of surface waters as related to soils and other environmental factors in a tundra ecosystem. Ph.D. Dissertation, Rutgers University, New Brunswick, NJ.

Billings, W.D., and K.M. Peterson. (1980). Vegetational change and ice wedge polygons through the thaw-lake cycle in arctic Alaska, Biological Report Series No. 14. Arctic and Alpine Research 12: 413-432.

Blackburn, A., H.M. Clilverd, R. Samuel, K. Holland, and D.M. White. (2007). Chemistry of North Slope, Alaska, lakes and reservoirs: September 2005 to May 2007, Report INE/WERC 07.13. Fairbanks, Alaska: University of Alaska Fairbanks, Water & Environmental Research Center.

Blackwell, S.B., C.R. Greene, and W.J. Richardson. (2004a). Drilling and operational sounds from an oil production island in the ice-covered Beaufort Sea. Journal of the Acoustical Society of America 116 5: 3199-3211.

Blackwell, S.B., R.G. Norman, C.R. Greene, Jr., M.W. McLennan, T.L. McDonald, and W.J. Richardson. (2004). Acoustic monitoring of bowhead whale migration, Autumn 2003. In: W.J. Richardson and M.W. Williams (Eds.). Monitoring of Industrial Sounds, Seals, and Bowhead Whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2003, Prepared by LGL, Ltd., King City, ON; Greeneridge Sciences, Inc., Santa Barbara, CA; and WEST, Inc., Cheyenne, WY, for BP Exploration (Alaska), Inc., Anchorage, AK. 7-1 – 7-45.

Blix, A.S. and J.W. Lentfer. (1992). Noise and vibration levels in artificial polar bear dens as related to selected petroleum exploration and developmental activities. Arctic 45 1: 20-24.

Bockstoce, J.R. (1986). Whales, ice, and men: the history of whaling in the western Arctic. Seattle, WA: University of Washington Press.

Bockstoce, J.R., and J.J. Burns. (1993). Commercial whaling in the North Pacific Sector. In: Burns, J.J., J.J. Montague, and C.J. Cowles (Eds.). The Bowhead Whale. Lawrence, KS: Society for Marine Mammalogy.

Boehm, P.D. (1987). Transport and transformation processes regarding hydrocarbon and metal pollutants in offshore sedimentary environments. In: Boesch, Donald F. and Nancy N. Rabalais (Eds.). Long-term environmental effects of offshore oil and gas development. New York: Elsevier Applied Science, Ltd.

Boreal Partners in Flight Working Group (BPIFWG). (1999). Landbird conservation plan for Alaska biogeographic regions, Version 1.0. Unpublished report. Anchorage, AK: U.S. Fish and Wildlife Service, 1999. Available online at: http://www.blm.gov/wildlife/plan/pl_ak_10.pdf Accessed November 2009.

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. (BPXA). (1995). Badami Development Project, Project Description and Environmental Assessment. Anchorage.

Bradstreet, M. S. W., K.J Finley, A.D Sekerak., W.B Griffiths., M.F Fabijan, C.R Evans, and H.E Stallard. (1986). Aspects of the biology of Arctic cod (*Boreogadus saida*) in Arctic Marine Food Chains. Canadian Technical Report of Fisheries and Aquatic Science 1491. pp. 193.

Braham, H.W., B.D. Krogman and G.M. Carroll. (1984). Bowhead and white whale migration, distribution, and abundance in the Bering, Chukchi, and Beaufort Seas, 1975-78, NOAA Technical Report NMFS SSRF-778. Washington, DC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Brandon, J. and P.R. Wade. (2004). Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales., Paper No. SC/56/BRG20. Unpublished paper submitted to the International Whaling Commission Scientific Committee.

Britch, R.P., R.C. Miller, J.P. Downing, T. Petrillo, and M. Vert. (1983). Physical processes. In: Gallaway, B.J. and R. P. Britch (Eds.) Environmental summer studies (1982) for the Endicott Development, Vol. II. LGL Alaska Research Associates, Inc., and Harding Technical Services. Report for SOHIO Alaska Petroleum Company, Anchorage, AK.

Britton, M.E. (1957). Vegetation of the arctic tundra. In: Hansen, H.P. (Ed.). Arctic biology. Corvalis, OR: Oregon State University Press.

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. Boulder, CO: Bureau of Land Management and National Oceanic and Atmospheric Administration, OCSEAP.

Broad, A.C., A. Benedict, K.H. Dunton, H. Koch, D.T. Mason, D.E. Schneider, and S.V. Schonberg. (1979). Environmental assessment of selected habitats in the Beaufort and Chukchi Seas littoral system. In: Environmental assessment of the Alaskan Continental Shelf: Principal Investigators' Reports for the Year Ending March 31, 1979. Boulder, CO, and Anchorage, AK: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program with U.S. Department of Interior, Bureau of Land Management 3 1979: 361-542.

Broad, A.C., H. Koch, D.T. Mason, D.M. Petri, D.E. Schneider, and E.J. Taylor. (1978). Environmental assessment of selected habitats in the Beaufort Sea littoral system. In: Environmental assessment of the Alaskan Continental Shelf: Principal investigators' reports for the year ending March 31, 1978. Boulder, CO: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program 5: 1-84.

Broad, A.C., H. Koch, D.T. Mason, D.M. Petri, D.E Schneider, and E.J. Taylor. (1981). Environmental assessment of selected habitats in the Beaufort Sea littoral system. In: Environmental assessment of the Alaskan Continental Shelf: Principal investigators' reports for the year ending March 31, 1981. Boulder, CO, and Anchorage, AK: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program with U.S. Department of Interior, Bureau of Land Management 1 1981: 401-620.

Brook, R.K., and E.S. Richardson. (2002). Observations of polar bear predatory behavior toward caribou. Arctic 55: 193-196.

Brower, C.D., A. Carpenter, M.L. Branigan, W. Calvert, T. Evans, A.S. Fischbach, J.A. Nagy, S. Schliebe, and I. Stirling. (2002). The polar bear management agreement for the Southern Beaufort Sea: An evaluation of the first ten years of a unique conservation agreement. Arctic 55: 362-372.

Brower, H.K. and R.T. Opie. (1997). North Slope Borough subsistence harvest documentation project - Nuiqsut, AK. July 1, 1994 - June 30, 1995. North Slope Borough Department of Wildlife Management. Barrow, AK. 45 pp.

Brower, H.K. and Raynita "Taqulik" Hepa. (1998). North Slope Borough subsistence harvest documentation project: data for Nuiqsut, Alaska, for the Period July 1, 1994, to June 30, 1995, Revised Ed. Barrow, AK: North Slope Borough, Department of Wildlife Management, 15 April 1998.

Brower, H.K., and R. Opie. (1996). North Slope Borough subsistence harvest documentation project: data for Anaktuvuk Pass, Alaska for the Period 1 July 1994, to 30 June 1995, Technical Report. Barrow, AK: Department of Wildlife Management, September 1996.

Brower, H.K., Jr. (2000). North Slope Borough subsistence harvest documentation project: data for Kaktovik, Alaska for the period 1 December 1994 to 30 November 1995, technical report. Barrow, AK: Department of Wildlife Management.

Brower, H.K., Jr., T. Olemaun, and R. Hepa. (2000). North Slope Borough subsistence harvest documentation project: data for Kaktovik, Alaska for the Period 1 December 1994 to 30 November 1995, Technical Report. Barrow, AK: Department of Wildlife Management.

Brown, J. (1967). Tundra soils formed over ice wedges, northern Alaska. Soil Science Society of America Journal 31: 686-691.

Brown, J. and R.A. Kreig. (1983). Guidebook to permafrost and related features along the Elliott and Dalton Highways, Fox to Prudhoe Bay, Alaska, Guidebook 4. Alaska Geological & Geophysical Surveys.

Brown, J., O.J. Ferrians, J.A. Heginbottom, and E.S. Melnikov. (1997). Circum-Arctic map of permafrost and ground ice conditions, U.S. Geological Survey Map CP-25. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. Revised February 2001.

Brown, J., R.K. Haugen, and S. Parrish. (1975). Selected climatic and soil thermal characteristics of the Prudhoe Bay Region. In: Brown, J. (Ed.). Ecological investigations of the tundra biome in the Prudhoe Bay Region, Special Report No. 2. Fairbanks, AK: Alaska Biological Papers of the University of Alaska.

Brown, S., J. Bart, R.B. Lanctot, J.A. Johnson, S. Kendall, D. Payer, and J. Johnson. (2007). Shorebird abundance and distribution on the Coastal Plain of the Arctic National Wildlife Refuge. Condor 109: 1-14.

Brown, W.E. (1978). Nuiqsut Paisanich: Nuiqsut heritage, a cultural plan. Prepared for the Village of Nuiqsut and the North Slope Borough Planning Commission on History and Culture. Anchorage, AK: University of Alaska, Arctic Environmental Information and Data Center.

Brueggeman, J.J. (1982). Early spring distribution of bowhead whales in the Bering Sea. Journal of Wildlife Management 46 4: 1036-1044.

Brueggeman, J.J., A. Cyr, S. McFarland, I.M. Laursen, and K. Lomak-McNair. (2009a). 90-Day report of the marine mammal monitoring program for the ConocoPhillips Alaska Shallow Hazards Survey Operations during the 2008 open water season in the Chukchi Sea. Seattle, WA: Canyon Creek Consulting, LLC, for Prepared for ConocoPhillips Alaska, Inc.

Brueggeman, J.J., B. Watts, M. Wahl, P. Seiser, A. Cyr. (2009b). (Draft) marine mammal surveys at the Klondike and Burger Prospects in the Chukchi Sea during the 2008 open water season. Prepared for ConocoPhillips Alaska, Inc., and Shell Offshore Inc.

Brueggeman, J.J., G.A. Green, R.A. Grotefendt, M.A. Smultea, D.P. Volsen, R.A. Rowlett, C.C. Swanson, C.I. Malme, R. Mlawski, and J.J. Burns. (1992). 1991 marine mammal monitoring program (Seals and Whales), Crackerjack and Diamond Prospects, Chukchi Sea. Bellevue, WA: EBASCO Environmental for Shell Western E & P, Inc., and Chevron USA, Inc.

Burch, E.S. Jr. (1976). The Nunamiut concept and the standardization of error. In: Contributions to Anthropology: The Interior Peoples of Northern Alaska. Edwin S. Hall, Jr. (ed.). Archaeological Survey of Canada Paper no. 49. National Museum of Man: Ottawa.

Bureau of Land Management (BLM). (2002). Final Environmental Impact Statement – renewal of the Federal Grant for the Trans Alaska Pipeline System Right-of-Way. U.S. Department of the Interior, Bureau of Land Management.

BLM. (2004). Alpine satellite development plan Final Environmental Impact Statement (FEIS). U.S. Department of Interior, Bureau of Land Management.

BLM. (2005a). Northeast National Petroleum Reserve – Alaska Final Amended Integrated Activity Plan/Environmental Impact Statement. Anchorage, AK: U.S. Department of Interior, Bureau of Land Management, January 2005. This may be viewed at: http://www.blm.gov/ak/st/en/prog/planning/npra_general/ne_npra/ne_npra_feis.htm

BLM. (2005b). Special status species list for Alaska, Instruction Memorandum No. AK 2006-03. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, 2005. Available online at: http://www.blm.gov/nhp/efoia/ak/2006im/im06-003.pdf. Accessed November 2007.

BLM. (2008). Northeast National Petroleum Reserve – Alaska, final supplemental integrated activity plan/environmental impact statement. Anchorage, AK: Bureau of Land Management.

BLM. (2008). Northeast National Petroleum Reserve – Alaska, final supplemental integrated activity plan/environmental impact statement. Anchorage, AK. Bureau of Land Management.

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, AK, by Science Applications Intl. Corp., Anchorage, AK.

Burgess, R. (2001). Unpublished data. ABR, Inc. Fairbanks, AK

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. Fairbanks, AK: University of Alaska.

Burgess, R.M. (2000). Arctic Fox. In: Truett, J.C. and S.R. Johnson (Eds.). The natural history of an Arctic oil field: development and the biota. San Diego, CA: Academic Press.

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 ConocoPhillips Alaska, Inc., Anchorage, AK.

Burgess, R.M., J.R. Rose, P.W. Banyas, and B.E. Lawhead. (1933). Arctic fox studies in the Prudhoe Bay Unit and adjacent undeveloped area, 1992. Unpublished report by Alaska Biological Research, Inc. for BP Exploration (Alaska) Inc., Anchorage.

Burns, J.J. (1970). Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. Journal of Mammalogy 51 3: 445-454.

Burns, J.J. (1990). Proceedings of a Technical Workshop on Fishes Utilized in Subsistence Fisheries in the National Petroleum Reserve – Alaska, October 26-28, 1988, Barrow, Alaska. Report to North Shore Bureau, Department of Wildlife Management, Barrow, Alaska.

Burns, J.J. (2003). Personal communication.

Buttrick, S.C. (1973). The ecological effects of vehicular traffic on frozen tundra. Thesis, Columbus, OH: Ohio State University.

Byrne, L.C., R.J. Ritchie, and D.A. Flint. (1994). Spectacled eider and tundra swan surveys: Kuvlum Corridor, Sagavanirktok River to Staines River. Unpublished Draft Report for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK.

Cade, T.J. (1960). Ecology of the peregrine and gyrfalcon populations in Alaska. University of California Publications in Zoology 63: 151-290.

Cameron et al. 1993 was incorrectly cited. Please see Cameron et al. 1992 for correct reference.

Cameron, R.D., W.T. Smith, R.G. White, and B. Griffith. (2002). Section 4: The Central Arctic Caribou Herd." In Arctic Refuge coastal plain terrestrial wildlife research summaries, D. C. Douglas, P. E. Reynolds, and E. B. Rhode, eds., pp. 38-45. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001.

Cameron, R.D., and J.M. Ver Hoef. (1994). Predicting parturition rate of caribou from autumn body mass. Journal of Wildlife Management 58: 674-679.

Cameron, R.D., and K.R. Whitten. (1979). Seasonal movements and sexual segregation of Caribou determined by aerial survey. Journal of Wildife Management 43: 626-633.

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., 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., W.T. Smith, R.G. White, and B. Griffiths. (2005). Central Arctic caribou and petroleum development: distributional, nutritional, and reproductive implications. Arctic 58: 1-9.

Campbell, W.B. (1981). Beaufort Sea barrier island-lagoon ecological process studies: Final report, Simpson Lagoon, Part 6. Primary production and nutrients. pp. 199-258 In: Environ. Assess. Alaskan Cont. Shelf. BLM/NOAA, OCSEAP, Final Report, Vol. 8.

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. 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.

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.

Carroll, G. (2001). Personal communication, North Slope Borough.

Carroll, G. (2007). Unit 26A, Teshekpuk Caribou Herd. In: Harper, P. (Ed.) Caribou Management Report of Survey and Inventory Activities 1 July 2004-30 June 2006, Project 3.0. Juneau, AK: Alaska Department of Fish and Game.

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, K. (2005). The effects of dissolved oxygen on steelhead trout, coho salmon, and chinook salmon biology and function by life stage. California Regional Water Quality Control Board. Shasta River TMDL Staff Report.

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.

Carter, L.D., O.J. Ferrians Jr., and J.P. Galloway. (1986a). Engineering-geologic maps of northern Alaska, coastal plain and foothills of the Arctic National Wildlife Refuge for the 1002 study area, open file report 86-3334. Anchorage, AK: U.S. Geological Survey.

Case, D. (1984). Alaska Natives and American laws. Fairbanks, AK: University of Alaska Press.

Caulfield, R. and T. Brelsford. (1999). Alaska: Subsistence policy history. NativeVet.

Caulfield, R., and T. Brelsford. (1991). Alaska: Subsistence policy history. NativeNet, Vol. 1999.

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, F.S., III, 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. In: Fox, M.W. (Ed.). The Wild Canids: Their Sytematics, Behavioral Ecology and Evolution. New York: Van Nostrand Reinhold.

Chin, H., M. Busdosh, G.A. Robillard and R.W. Firth, Jr. (1979a). 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.

Chin, Niedoroda, Robilliard, and Busdosh. (1979b). In Prudhoe Bay waterflood project—Biological effects of impingement and entrainment from operation of proposed intake. (WCC).

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 1982-1987. Canadian Journal of Zoology 67: 2646-2654.

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, Vol. 1. Washington, DC: U.S. Fish and Wildlife Service, U.S. Geological Survey, and Bureau of Land Management.

Coady, J. W. (1980). History of moose in northern Alaska and adjacent regions. Canadian Field-Naturalist 94: 61-68.

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, Technical Paper No. 120. Alaska Department of Fish and Game.

Colonell, J.M. and B.J. Gallaway. (1997). Wind-driven transport and dispersion of Age-0 Arctic ciscoes along the Alaska Beaufort coast. Pages 90-103 In: J. Reynolds, editor. Fish ecology in Arctic North America. American Fisheries Society Symposium 19, Bethesda, Maryland.

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.

Combellick, R.A. (1994). Geologic Hazards In and Near Proposed State of Alaska Oil and Gas Lease Sale 80 (Shaviovik), Public Data File 94-8. Division of Geological & Geophysical Surveys, January.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. (1979). Classification of wetlands and deepwater habitats of the United States, FWS/OBS-79-31. U. S. Department of the Interior, U.S. Fish and Wildlife Service.

Craig 1987 was incorrectly cited. Please disregard.

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 pp.

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. (1989a). 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. (1989b). Subsistence fisheries at coastal villages in the Alaskan Arctic, 1970-1986. Biological Papers of the University of Alaska 24: 131-152.

Craig, P.C. and L. Haldorson. (1986). Pacific salmon in the North American Arctic. Arctic 39 1: 2-7.

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.J. 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.

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.

Critchlow, K.R. (1983). Fish study. In: Prudhoe Bay Waterflood Environmental Monitoring Program 1982. Unpublished report by Woodward-Clyde Consultants. Available at U.S. Army Corps of Eng., Anchorage, AK. 327 pp. + Append.

Cronin, M.A., S.C. Amstrup, and K.T. Scribner. (2006). Microsatellite DNA and Mitochondrial DNA Variation in polar bear (*Ursus maritimus*) from the Beaufort and Chuckchi Seas, Alaska. Canadian Journal of Zoology 84 5: 655-660.

Cronin, M.A., W.B. Ballard, J. Truett, and R. 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.

Curatolo, J.A., and A.E. Reges. (1985). The calving ground of the central Arctic caribou herd, 1984. Final report prepared for ARCO Alaska, Inc., Anchorage, AK, by Alaska Biological Research, Inc.

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, AK, for ARCO Alaska, Inc., Anchorage, AK.

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.

Curtis, M.A. (1975). The marine benthos of arctic and sub-arctic continental shelves. Polar Rec 17: 595-626.

Dames & Moore, and J. Lobdell. (1986). Annotated bibliography: Point Thomson Project. Exxon Company, USA.

Dames & Moore. (1983). Data report: Point Thomson Development, Alaska 1983 Hydrology Program. Prepared for Exxon Company, USA, Production Department, Western Division, Golden, CO.

Danell, L., and K. Sjoberg. (1982). Successional patterns of plants, invertebrates, and ducks in a man-made lake. Journal of Applied Ecology 19: 395-409.

Darigo, N., O. Mason, P. Bowers. (2007). Final report: review of geological/geophysical data and core analysis to determine archaeological potential of buried landforms, Beaufort Sea Shelf, Alaska. OCS Study MMS 2007-004, Minerals Management Service, Anchorage.

Dau, C., and W.W. Larned. (2007). Aerial population survey of common eiders and other waterbirds in near shore waters and along Barrier Islands of the Arctic Coastal Plain, Alaska, 22-24 June 2007. Unpublished report, U.S. Fish and Wildlife Service, Anchorage, AK.

Dau, J R. (1986). Distribution and behavior of barren-ground caribou in relation to weather and parasitic insects. M.S. thesis. Fairbanks, AK. University of Alaska.

Dau, J.R., and R.D. Cameron. (1986). Effects of a road system on caribou distribution during calving. Rangifer Special Issue. 95-101.

Davidson, A. (1974). Education and the subsistence way of life. Alaska Native Knowledge Network. Vol. 1999.

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. Report from LGL Ltd., Toronto, Ontario, for Sohio Alaska Petroleum Company, Anchorage, AK, and Dome Petroleum Ltd., Calgary, AB (co-managers).

Dawson, C.W. (1916). Clair W. Dawson papers. Accession no. 204, Glenbow-Alberta Institute Archives Division, Calgary.

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.

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., A.K. Prichard, and J.R. Rose. (2005). Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska: 2001-2004. Final report for BP Exploration (Alaska) Inc., Anchorage, AK, by ABR, Inc.–Environmental Research & Services, Fairbanks, AK. 142 pp.

Day, R.H., A.K. Prichard, J.R. Rose, and A.A. Stickney. (2003). Migration and collision avoidance of eiders and other birds at Northstar Island, Alaska, 2001 and 2002. Final Report, prepared for BP Exploration (Alaska) Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 128 pp.

Day, R.H., A.K. Prichard, L.B. Attanas, J.E. Shook, and B.A. Anderson. (2007). Mortality of birds at powerlines: a guide for studies in northern Alaska. Final Report, prepared for BP Exploration (Alaska) Inc., Anchorage, AK, by ABR, Inc.—Environmental Research and Services, Fairbanks, AK. 136 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.

DeMaster, D.P. (1995). Minutes from the 4-5 and 11 January 1995 meeting of the Alaska Scientific Review Group. Anchorage, AK, 1995. Available upon request - D.P. DeMaster, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

Denfield, D.C. (1994). The Cold War in Alaska: a management plan for cultural resources, 1994-1999. With contributions by Jennifer Abel, Dale Slaughter. Manament Plan for Cultural Resources. U.S. Army Corps of Engineers, Alaska District.

Derksen, D.V., and W.D. Eldridge. (1980). Drought-displacement of pintails to the Arctic coast plain. Alaska. J. Wildlife Manage 44: 224-229.

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 the Interior, Fish and Wildlife Service, Washington, D.C. Resource Publication 141, 27 pp.

Derocher, A.E., O. Wiig, and G Bangjord. (2000). Predation of Svalbard reindeer by polar bears. Polar Biology 23: 675-678.

DFO Science. (2002). Big Fish River dolly varden. Stock Status Report D5-60. Fisheries and Oceans Canada. pp. 15.

Dickins, D. (2006). 2006 Svalbard experimental spill to study spill detection and oil behaviour in ice: Summary field report. U.S. Department of Interior, Minerals Management Service. Submitted by D.F. Dickins Associates, Ltd., SINTEF; The University Centre at Svalbard (UNIS); and Boise State University.

Dickson, L.D. (1994). Nesting habitat of the red-throated loon, *Gavia stellata*, at Toker Point, Northwest Territories. Canadian Field-Naturalist 108: 10-16.

Division of Governmental Coordination (DGC). (1985). Biophysical boundaries for Alaska's coastal zone. Alaska Coastal Management Program, Division of Governmental Coordination, Office of Management and Budget.

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.

Douglass, R.J. (1977). Effects of winter roads on small mammals. Journal of Applied Ecology 14: 827-834.

Dunton, K.H. (1984). An annual carbon budget for an arctic kelp community. pp. 311-325 In: P.W. Barnes, D.M. Schell, and E. Reimnitz (Eds.), The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press Inc., New York, NY. 466 pp.

Durner, G.M., (2009). Personal communication.

Durner, G.M., D.C. Douglas, R.M. Nielson, S.C. Amstrup, T.L. McDonald, I. Stirling, M. Mauritzen, E. W. Born, O. Wiig, E. DeWeaver, M.C. Serreze, S.E. Belikov, M.H. Holland, J. Maslanik, J. Aars, D.A. Bailey, and A.E. Derocher. (2009). Predicting 21st-century polar bear habitat distribution from global climate models. Ecological Monographs 79: 25-58.

Durner, G.M., S.C. Amstrup, and A.S. Fischbach. (2003). Habitat characteristics of polar bear terrestrial maternal den sites in northern Alaska. Arctic 56: 55-62.

Durner, G.M., S.C. Amstrup, and K.J. Ambrosius. (2001). Remote identification of polar bear maternal den habitat in northern Alaska. Arctic 56: 55-62.

Durner, G.M., S.C. Amstrup, and K.J. Ambrosius. (2006). Polar bear maternal den habitat in the Arctic National Wildlife Refuge, Alaska. Arctic 59: 31-36.

Durner, G.M., S.C. Amstrup, R. Nielson, and T. McDonald. (2004). The use of sea ice habitat by female polar bears in the Beaufort Sea. OCS Study MMS 2004-014. U.S. Department of Interior, Minerals Management Service, Anchorage, AK, 41 pp.

Dyck, M. (2006). Characteristics of polar bears killed in defense of life and property in Nunavut, Canada, 1970-2000. Ursus 17: 52-62.

Earnst, S.L. (2004). Status assessment and conservation plan for the yellow-billed loon *(Gavia adamsii).* Scientific Investigations Report 2004-5258, by U.S. Department of the Interior, U.S. Geological Survey, Reston, VA, 42 pp.

Earnst, S.L., R.M. Platte, and L. Bond. (2006). A landscape-scale model of yellow-billed loon (*Gavia adamsii*) habitat preferences in northern Alaska. Hydrobiologia 567: 227-236.

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., 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., 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.

Eberhardt, W.L. (1977). The biology of Arctic and red foxes on the North Slope. M.S. Thesis, University of Alaska, Fairbanks, 125 pp.

Ebersole, J.J., and P.J. Weber. (1983). Biological decomposition and plant succession following disturbance on the Arctic Coastal Plain, Alaska. In: Permafrost: Fourth International Conference Proceedings, 17-22 July 1983, pp. 266-271. University of Alaska, Fairbanks. Washington, D.C.: National Academy Press.

Ellanna, L.J. and G.K. Sherrod. (1983.) The role of kinship links in subsistence production: Some Implications for Community Organization. Juneau, AK: Alaska Department of Fish and Game.

Ellis, D.V. (1955). Some observations on the shore fauna of Baffin Island. Arctic 8: 224-236.

Ellsworth, W.L, M. Celebi, J.R. Evans, E.G. Jensen, R. Kayen, M.C. Metz, D.J. Nyman, J.W. Roddick, P. Spudich, and C.D. Stephens. (2004). Near-field ground motion of the 2002 Denali Fault, Alaska, earthquake recorded at pump station 10: Earthquake Spectra, 20, No. 3: 597-615.

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.

ENSR (consulting and engineering). (1991). Endicott development project NPDES monitoring program permit no. AK-003866-1: Sediment quality and benthic macroinvertebrate monitoring, 1990 studies. Unpublished manuscript. Available at BP Exploration (Alaska) Inc., Anchorage, AK.

Environmental Protection Agency (EPA). (1998). Selected revised sections of the proposed guidelines for carcinogen risk assessment. Washington, DC: National Center for Environmental Assessment, Office of Research and Development.

EPA. (2009a). Cleanups in my community database, EPA, August 31, 2009. Available online at: http://iaspub.epa.gov/Cleanups/.

EPA. (2009b). Inventory of U.S. greenhouse gas emissions and sinks: 1990 - 2007, EPA 430-R-09-004. Washington, DC: U.S. Environmental Protection Agency, 15 April 2009. Available online at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

ESRI. (1999). ARC News. Available online at: http://www.esri.com/news/arcnews/fall99articles/31-alaska.html.

Evans, T. (2009). Personal communication.

ExxonMobil (Exxon Mobil Corporation). (2003). Point Thomson preliminary draft environmental impact statement.

ExxonMobil (Exxon Mobil Corporation). (2008). 2008 corporate citizenship report. Irving, TX.

ExxonMobil (Exxon Mobil Corporation). (2009a). Point Thomson Project description. October, 2009.

ExxonMobil (Exxon Mobil Corporation). (2009b). Draft Point Thomson Project Department of the Army Application for Permit. October, 2009.

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: 44-650.

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. pp.138.

Fay, F.H. (1974). The role of ice in the ecology of marine mammals of the Bering Sea. In Oceanography of the Bering Sea, D. W. Hood and E. J. Kelley, (Eds.), pp. 383-399. University of Alaska, Fairbanks.

Fay, F.H. (1982). Ecology and biology of the Pacific walrus (*Odobenus rosmarus divergens Illiger*). North American Fauna 74. Washington, DC: U.S. Fish and Wildlife Service.

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. 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., and W.B. Griffiths. (2001). Pacific salmon in the Beaufort Sea, 2001: A synopsis. Report to Exploration (Alaska), Inc., Anchorage, Alaska. pp. 21.

Fechhelm, R.G., B.E. Haley, G.B. Buck, G.D. Wade and M.R. Link. (2005). Nearshore Beaufort Sea fish monitoring in the Prudhoe Bay region, 2004. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, AK. 72 p + Append.

Fechhelm, R.G., R.E. Dillinger, Jr., B.J. Gallaway, and W.B. Griffiths. (1992). Modeling of in situ growth and temperature relationships of yearling broad whitefish in Prudhoe Bay, Alaska. Transactions of the American Fisheries Society 121 1: 1-12.

Fechhelm, R.G., S.W. Raborn, and M.R. Link. (2009). Year 26 of the long-term monitoring of nearshore Beaufort Sea fishes in the Prudhoe Bay region: 2008 annual report. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska. pp. 79.

Fechhelm, R.G., W.B. Griffiths, B.E. Haley, and M.R. Link. (2004). Nearshore Beaufort Sea fish monitoring in the Prudhoe Bay region, 2003. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, AK. 73 p + Append.

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 report. 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. *In:* The Nearshore Marine Environment in Prudhoe Bay, Alaska, Vol. 1, Report R767. Fairbanks, AK: Institute of Marine Science, University of Alaska.

Federal Aviation Administration (FAA). (2008). Form 5010 airport master record. Available online at: http://www.gcr1.com/5010web/REPORTS/SCC.pdf

Federal Highway Administration (FHWA). (1981). U.S. Department of Transportation, Federal Highway Administration. Visual impact assessment for highway projects (FHWA-HI-88-054). This document is currently not available on the FHWA Web site. Available online at: http://www.dot.ca.gov/ser/guidance.htm#visual.

Federal Register (FR). (1981). Title 36: Parks, forests, and public property-Chapter 1: National Park Service, U.S. Department of the Interior, Part 60: National Register of Historic places; 16 November 1981. Title 36, Code of Federal Regulations, Part 60.4 (36 CFR 60.4). Federal Register Vol. 46, p. 56187.

Felix, N.A., and M.K. Raynolds. (1989). The effects of winter seismic trails on tundra vegetation in northeastern Alaska, USA. Arctic and Alpine Research 21 (1989): 188-202.

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.

Ferguson, S.H., M.K. Taylor, and F. Messier. (2000). Influence of sea ice dynamics on habitat selection by polar bears. Ecology 81 (2000): 761-772.

Ferrians, O.J. (1965). Permafrost map of Alaska. U.S. Geological Survey. Miscellaneous Geologic Investigations Map I- 445. Scale 1:2,500,000.

Field, R.F., J. Gerhardt, J. Tande, G. Balogh, R. McAvinchey, and J. Bart. (1988). Bird–habitat associations on the North Slope, Alaska, 1987 progress report for the U.S. Fish and Wildlife Service, Alaska Investigations, Branch of Wetlands and Marine Ecology, Anchorage, AK.

Fine, H. (1980). Ecology of arctic foxes at Prudhoe Bay, Alaska. M.S. Thesis, University of Alaska Fairbanks, 76 pp.

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. and C.R. Evans. (1983). Summer diet of the bearded seal (*Erignathus barbatus*) in the Canadian High Arctic. Arctic 36: 82-89.

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.

Fischbach, A.S., S.C. Amstrup, and D.C. Douglas. (2007). Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. Polar Biology 30: 1395-1405.

Fischer, J.B, T.J. Tiplady, and W.W. Larned. (2002). Monitoring Beaufort Sea waterfowl and marine birds, aerial survey component. Report prepared for Minerals Management Service, Anchorage, AK, by U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK. OCS Study, MMS 2002-002, 36 pp.

Fischer, J.B. and W.W. Larned. (2004). Summer distribution of marine birds in the western beaufort sea. Arctic 57: 143-159.

Flint, P., J. Reed, D. Lacroix, J. C. Franson, T. Hollmén, and S. Sonsthagen. (2002). Monitoring Beaufort Sea waterfowl and marine birds, 2002 Annual Progress Report. Report prepared for Minerals Management Service, Anchorage, AK, by U. S. Geological Survey, Anchorage, AK, 57 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., J.A. Reed, J.C. Franson, T.E. Hollmen, J.B. Grand, M.D. Howell, R.B. Lanctot, D.L. Lacoix, C.P. Dau. (2003). Monitoring Beaufort Sea waterfowl and marine birds. Prepared by USGS Alaska Science Center, Anchorage, Alaska, (Alaska OCS Study MMS 2003-037) for the U.S. Department of the Interior, Minerals Management Service, Anchorage, AK.

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.

Follmann, E.H. (1989). The importance of advance planning to minimize bear-people conflicts during large-scale industrial and transportation developments in the North. In: Bear-people conflicts: Proceedings of a symposium on management strategies, M. Bromley, (Ed.), pp. 105-110. 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.

Ford, J., and Bedford, B.L. (1987). The hydrology of Alaskan wetlands. USA – A review: Arctic and Alpine Research, v. 19, No. 3, p. 209-229.

Fried, N. (2008). Alaska’s oil industry, Alaska economic trends, September 2008. Available online at: http://labor.alaska.gov/research/trends/sep08ind.pdf

Frost, K.J. (1985). The ringed seal. Unpublished Report, Fairbanks, AK: Alaska Department of Fish and Game.

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.), pp. 43-46. Chena Hot Spring, AK, April 21-23, 1981. Juneau, AK: USDOC, NOAA, and USDOI, MMS.

Frost, K.J. and L.F. Lowry. (1988.) Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. In: W.M. Sackinger, M.O. Jefferies, J.L. Imm, and S.D. Treacy (Eds.), Port and Ocean Engineering Under Arctic Conditions, Volume II: Symposium on Noise and Marine Mammals. Fairbanks, AK: University of Alaska Fairbanks, Geophysical Institute.

Frost, K.J., L.F. Lowry, and G. Carroll. (1993). Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46: 8-16.

Frost, K.J., L.F. Lowry, G. Pendleton, and H.R. Nute. (2002). Monitoring distribution and abundance of ringed seals in northern Alaska, OCS Study, MMS 2002-043. Final report from the Alaska Department of Fish and Game, Juneau, AK, for U.S. Department of Interior, Minerals Management Service, Anchorage, AK.

Frost, K.J., L.F. Lowry, G. Pendleton, and H.R. Nute. (2004). Factors affecting the observed densities of ringed seals, *Phoca hispida,* in the Alaskan Beaufort Sea, 1996-99. Arctic 57: 115-128.

Frost, G.V., R.J. Ritchie, and T. Obritschkewitsch. (2007). Spectacled and Steller's eiders surveys at U.S. Air Force radar sites in northern Alaska, 2006. Unpublished report prepared for the U.S. Air Force, Elmendorf Air Force Base, Alaska, by ABR, Inc., Fairbanks, AK.

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. pp. 69.

Fuller, A.S. and J.C. George. (1997). Evaluation of subsistence harvest data from the North Slope Borough 1993 census for eight North Slope villages for the calendar year 1992. North Slope Borough, Dept. Wildlife Management, Barrow, AK.

Furniss, R.A. (1974). Inventory and cataloging of arctic area waters. Alaska Dept. of Fish and Game Annual Report no. 15, Juneau, AK. pp. 1-15.

Fyfe, J.D. (2003). Separating extratropical zonal wind variability and mean change. Journal of Climate 16: 863-874.

Galginaitis, M. (1990a). 1990 Subsistence resource harvest patterns: Kaktovik. Special Report No. 8. OCS Study MMS 90-0038. Prepared by Impact Assessment Inc. for the United States Department of the Interior, Minerals Management Service, Alaska OCS Region: Anchorage, AK.

Galginaitis, M. (1990b). 1990 Subsistence Resource Harvest Patterns: Nuiqsut. Special Report No. 9. OCS Study MMS 90-0038. Prepared by Impact Assessment Inc. for the United States Department of the Interior, Minerals Management Service, Alaska OCS Region: Anchorage, AK.

Galginaitis, M. (2009). Annual Assessment of Subsistence Bowhead Whaling Near Cross Island, 2001-2007: canimida task 7 final report. OCS Study MMS 2009-038. Prepared by Applied Socioucltural research for USDOI, MMS, Alaska OCS Region. Anchorage.

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.

Galginaitis, M.C., G.P. Bowers, and C. Wooley. (2001). Subsistence. In: Environmental report for Trans Alaska Pipeline System right-of-way, Volume 1. Trans Alaska Pipeline System Owners.

Gallaway, B.J. and R. Fechhelm. (2000). Anadromous and amphidromous fishes. In: J. Truett (ed.) The natural history of an arctic oilfield. Academic Press. pp. 349-369.

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.

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.

Garner, G.W., and H.V. Reynolds (Eds.). (1986). Arctic National Wildlife Refuge coastal plain resource assessment, 1985 update report— baseline study of the fish, wildlife, and their habitats, Vol. 2. Anchorage, AK: U.S. Fish and Wildlife Service.

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. FY 86-12. In: Garner, G.W. 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. Anchorage, AK: U.S. Fish and Wildlife Service.

Garrott, R.A. (1980). Den characteristics, productivity, food habits, and behavior of arctic foxes in northern Alaska. M.S. 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, C. (2006). Personal communication.

George, C.J., J. Zeh, R. Suydam, and C. Clark. (2004a). Abundance and population trends (1978-2001) of western Arctic bowhead whales (*Balaena mysticetus*) surveyed near Barrow, Alaska. Marine Mammal Science 20: 755-773.

George, C.J., R. Suydam, J. Zeh, and W. Koski. (2004b). Estimated pregnancy rates of bowhead whales from examination of landed whales, Paper No. SC/56/BRG10. Paper presented to the International Whaling Commission Scientific Committee.

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. pp. 35.

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.

Geraci, J.R. and D.J. St. Aubin. (1990). Sea mammals and oil: Confronting the risks. San Diego, CA: Academic Press, Inc.

Gibson Energy ULC. (2008). Natural gas condensate (sweet) material safety data sheet, 31.

Gilbert, J., G. Fedoseev, D. Seagars, E. Razlivalov, and A. LaChugin. (1992). Aerial census of pacific walrus, 1990, R7/MMM Technical Report 92-1. Anchorage, Alaska: U.S. Fish and Wildlife Service, Marine Mammal Management.

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. pp. 188.

Goetz, K, K., D. Rugh, and J. Mocklin. (2009). Bowhead whale feeding ecology study, aerial surveys, 2008 July, August, September. Quarterly report. Interagency agreement number MMS 4500000120, 8 pp.

Goetz, K.T., D.J. Rugh, and J.A. Mocklin. (2008). Bowhead whale feeding ecology study (BOWFEST), Aerial Surveys: 2008 July, August, September. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory, Cetacean Assessment and Ecology Program Quarterly Report. Interagency Agreement Number MMS 4500000120.

Goldsmith, S. (2008). What drives the Alaska economy? UA Research Summary No. 13. 4 pp.

Gollop, M.A., and R.A. Davis. (1974). Gas compressor noise simulator disturbance to snow geese, Komakuk Beach, Yukon Territory, September, 1972. Chapter 8, Arctic Gas Biological Report Series. No. 14.

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. Chapter 2, Arctic Gas Biological Report Series. No. 14.

Grantz, A., D.A. Dinter, and N.N. Biswas. (1983). Map, cross sections, and chart showing late quaternary faults, folds, and earthquake epicenters on the Alaskan Beaufort Shelf, miscellaneous investigations series I-1182C. U.S. Geological Survey.

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. pp. 150.

Greene, C.R., Jr. (1997). Physical acoustics measurements. In: W. John Richardson (Ed.), Northstar marine mammal marine monitoring program, 1996: Marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea, Report TA2121-2, Chapter 3, from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Exploration (Alaska), Inc., Anchorage, AK, and U.S. National Marine Fisheries Service Anchorage, AK, and Silver Spring, MD.

Greene, C.R., Jr., N.S. Altman, and W.J. Richardson. (1999). Bowhead whale calls In: W. John Richardson (Ed.), Marine mammal and acoustical monitoring of western geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998, LGL Report TA2230-3. Report from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD.

Greene, C.R., M.R. Link, and R. Rodrigues. (2009). Bowhead whale call locations north of the Oooguruk and Spy Island Drillsites, 12 August-6 October 2008. In: Link, M.R., and R. Rodrigues (Eds.). Monitoring of In-water Sounds and Marine Mammals Near the Oooguruk and Nikaitchuq Developments in Eastern Harrison Bay, Alaskan Beaufort Sea, 2008. Report from LGL Alaska Research Associates, Inc., Anchorage, AK; Greeneridge Sciences Inc., Santa Barbara, CA; and Jasco Research Ltd., Victoria, BC; for Pioneer Natural Resources Alaska Inc., Anchorage, AK, and Eni US Operating Co. Inc., Anchorage, AK.

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.

Griffith, B., D.C. Douglas, N.E. Walsh, D.D. Young, T.R. McCabe, D.E. Russell, R.G. White, R.D. Cameron, and K.R. Whitten. (2002). Section 3: The porcupine caribou herd. In: Arctic Refuge coastal plain terrestrial wildlife research summaries, D.C. Douglas, P.E. Reynolds, and E.B. Rhode, (Eds.). U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001.pp. 8-37

Griffiths, W.B, R.G. Fechhelm, B.J. Gallaway, L.R. Martin, and W.J. Wilson. (1995a). 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, R.G. Fechhelm, L.R. Martin, W.J. Wilson, and J.M. Colonell. (1995b). The 1994 Endicott development fish monitoring program. Vol. I: Fish and Hydrography Data Report. Report for BP Exploration (Alaska) Inc. and North Slope Borough. 182 pp. + Append.

Griffiths, W.B. (1983). Fish. 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. pp. 176-222

Griffiths, W.B. and B.J. Gallaway. (1982). Prudhoe Bay waterflood fish monitoring program 1981. Unpublished report by LGL Alaska Research Associates. Available at U.S. Army Corps of Eng., Anchorage, AK. pp. 143.

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. Report Ser. 40. pp. 190.

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. pp. 219.

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. Unpublished report. by LGL Alaska Research Assoc., Inc. Available at BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK, 99519. pp. 180 + 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. Unpublished report by LGL Alaska Research Assoc., Inc. Available at BP Exploration (Alaska) Inc., P.O. Box 196612, Anchorage, AK, 99519. pp. 193 + Append.

Grinage 2004 was incorrectly cited. Please disregard.

Grosvenor 1902 was cited incorrectly. Please see Grosvenor 1903 for correct reference.

Grosvenor, G.H. (1903). Reindeer in Alaska. Government Printing Office: Washington D.C.

Hall, W.J., D.J. Nyman, E.R. Johnson, and J.D. Norton. (2003). Performance of the Trans-Alaska Pipeline in the November 3, 2002 Denali fault earthquake: Proceedings of the Sixth U.S. Conference and Workshop on Lifeline Earthquake Engineering, ASCE Technical Council on Lifeline Earthquake Engineering, Long Beach, CA, TAPS-0. p. 1-13.

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.

Hansen, D.J. (1985). The potential effects of oil spills and other chemical pollutants on marine mammals occurring in Alaskan waters. MMS 85-0031. US Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Harcharek, J. (1999). Personal communication. North Slope Borough Commission on Inupiat History Language and Culture.

Harcharek, R. (1995). North Slope Borough 1993-1994 economic profile and census report, Volume VII. Barrow, AK: North Slope Borough, Department of Planning and Community Services.

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.

Harper, P. (Ed.) (2007). Muskox management report of survey-inventory activities 1 July 2004-30 June 2006. Juneau, AK: Alaska Department of Fish and Game, 2007.

Harris, C.M., (Ed.) (1991). Handbook of acoustical measurements and noise control, third edition. New York, NY: McGraw-Hill, Inc.

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 the West Amundsen Gulf During Late July 1992. Canadian Journal of Fisheries and Aquatic Sciences 53: 2,262-2,273.

Hashagen K.L., G.A. Green, and B. Adams. (2009). Observation of humpback whales in the Beaufort Sea, Alaska. Northwest Naturalist 90:160-162.

Haskell, S.P., R.M. Nielson, W.B. Ballard, M.A. Cronin, and T.L. McDonald. (2006). Dynamic responses of calving caribou to oilfields in northern Alaska. Arctic 59: 179-190.

Hassol, S.J. (2004). Impacts of a warming Arctic: Arctic climate impact assessment. Produced by Arctic Climate Impact Assessment. Cambridge, UK: Cambridge University Press.

Haveolook, H. (1977). Kaktovik on Barter Island: a brief history of Kaktovik and its schools. Prepared for the Education Hearings during the first Inuit Circumpolar Conference, held in Barrow, Alaska. June 13-17, 1977.

Hawkins, L. L. (1986). Tundra swan (*Cygnus columbianus columbianus*) breeding behavior. Thesis, University of Minnesota, St. Paul, Minnesota. 145 pp.

Hazard, K. (1988). Beluga whale, *Delphinapterus leucas.* In: Lentfer, J.W. (Ed.), Selected marine mammals of Alaska: Species accounts with research and management recommendations. Washington, DC: Marine Mammal Commission.

Hegna, J. (2009). Personal interview, 24 September 2009.

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 pp.

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. pp. 18.

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.

Hinzman, L.D., M.R. Lilly, D.L. Kane, D.D Miller, B.K. Galloway, K.M. Hilton, and Daniel M. White. (2006). Physical and chemical implications of mid-winter pumping of tundra lakes – North Slope, Alaska, Report INE/WERC 06.15. Fairbanks, Alaska: University of Alaska Fairbanks, Water and Environmental Research Center.

Hobson, K.A. and H.E Welch. (1992). Determination of trophic relationships within a high-arctic marine food web using Δ13C and Δ 15N analysis. Marine Ecological Progress Series 84: 9-18.

Hoefler Consulting Group, Inc. (HCG). (2007a). Application for a prevention of significant deterioration construction permit for the Liberty development project. Prepared for BP Exploration (Alaska), Inc.

HCG, Inc. (2007b). Study final report for the nearshore Beaufort Sea meteorological monitoring and data synthesis project, OCS Study MMS 2007-011. Prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. Available online at: http: //www.mms.gov/alaska/reports/2007rpts/2007_011/ 2007_011.pdf

Hoffman, D.D. Libby, and 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 Birds 25: 73-103.

Holland, M.M., C.M. Bitz, and B. Tremblay. (2006). Future abrupt reductions in the summer Arctic Sea ice. Geophysical Research Letters 33 L23503.

Hollmen, T.E., J.C. Franson, P.L. Flint, J.B. Grand, R.B. Lanctot, D.E. Docherty, and H.M. Wilson. (2003). An adenovirus linked to mortality and disease in long-tailed ducks *(Clangula hyemalis)* in Alaska. U.S. Geological Survey, National Wildlife Health Center, Madison, Wyoming.

Hopsen, E. (1976). Mayor Eben Hopsen's warning to the people of the Canadian Arctic. Testimony to the Berger Commission.

Hopsen, E. (1978). Mayor Eben Hopsen's testimony, public hearing on proposed Point Thomson Lease Sale, July 25.

Horner, R. (1984). Phytoplankton abundance, chlorophyll a, and primary productivity in the western Beaufort Sea. pp. 295-310 In: P.W. Barnes, D.M. Schell, and E. Reimnitz (Eds.), The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press Inc., New York, NY. 466 p.

Horner, R.A., and G.C. Schrader. 1981. Primary production in the nearshore Beaufort Sea in winter-spring: Contribution from ice algae, phytoplankton, and benthic microalgae. Environ. Assess. Alaskan Cont. Shelf, BLM/NOAA, Manuscript RU 0359.

Hsiao, H.I.C. (1976). Biological productivity of the southern Beaufort Sea: Phytoplankton and seaweed studies. Beaufort Sea Project Technical Report No. 12C, Environment Canada, Victoria, B.C. 99 pp.

Huguenin, M.T., D.H. Huary, J.C. Weiss, D. Helton, C. Manen, E. Reinhar, and J. Michel. (1996). Injury Assessment: Guidance document for natural resource damage assessment under the Oil Pollution Act of 1990. Prepared by Industrial Economics, Inc., Cambridge, MA: Damage Assessment Center, National Oceanic and Atmospheric Administration, Silver Spring, MD; and Research Planning, Inc., Columbia, SC, for the Damage Assessment Remediation and Restoration Program, National Oceanic and Atmospheric Administration, Silver Spring: Maryland.

Hupp, J.W., D.G. Robertson, and A.W. Brackney. (2002). Snow geese. In: Arctic Refuge coastal plain terrestrial wildlife research summaries, D.C. Douglas, P.E. Reynolds, and E.B. Rhode, (Eds.), U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001. pp. 71-74.

Hydrocon Engineering Continental Ltd. (Hydrocon). (1982). Point Thomson development hydrologic studies. Prepared for Exxon Company, USA, Production Department, Western Region, Calgary, AB.

Impact Assessment Inc. (IAI). (1988). Village economies in rural Alaska, Alaska OCS technical studies program technical report No. 132. Anchorage, AK: U.S. Department of Interior, Minerals Management Service, Alaska OCS Region.

IAI. (1989). Point Lay case study, OCS Study, MMS 89-0093. Social and economic studies program technical report No. 139. Prepared by Impact Assessment, Inc., of La Jolla, CA, for U.S. Department of Interior, Minerals Management Service, Alaska OCS Region, Social and Economic Studies Program, Anchorage, AK.

IAI. 1990 was cited incorrectly. Please see IAI 1990a for correct reference.

IAI. (1990a). Subsistence resource harvest patterns: Kaktovik, special report No. 8, OCS Study MMS 90-0038. Prepared for the U.S Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

IAI. (1990b). Subsistence resource harvest patterns: Nuiqsut, special report No. 9, OCS Study MMS 90-0038. Prepared for the U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

IAI. 1993 was cited incorrectly. Please see IAI 1990a for correct reference.

IAI. (2001). Exxon Valdez oil spill, cleanup and litigation: A collection of social impacts information and analysis, final report. Prepared by J.C. Russell, M.A. Downs, B.R. Strick, and M.S. Galginaitis. Prepared for U.S. Department of the Interior, Minerals Management Service. Alaska OCS Region Environmental Studies Section. Technical Report No. 161. LaJolla, California.

Intergovernmental Panel on Climate Change (IPCC). (2007). Climate Change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (Eds.). Cambridge, UK, and New York, NY: Cambridge University Press.

Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (Eds). (2008). Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2007, LGL Alaska Report P97-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., JASCO Research, Ltd., and Geeneridge Sciences, Inc., for Shell Offshore Inc., ConocoPhillips Alaska, Inc., National Marine Fisheries Service, and U.S. Fish and Wildlife Service.

Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (Eds). (2009). Joint monitoring program in the Chukchi and Beaufort Seas, July-November 2007. LGL Alaska Report P97-1, Report from LGL Alaska Research Associates, Inc., LGL Ltd., JASCO Research, Ltd, and Geeneridge Sciences, Inc. for Shell Offshore Inc.,ConocoPhillips Alaska, Inc., National Marine Fisheries Service, and United States Fish and Wildlife Service. 445p. plus Appendices.

Jackson, S. (1904). Thirteenth annual report on introduction of reindeer into Alaska (1903). Government Printing Office: Washington D.C

Jacobson, M.J. and C. Wentworth. (1982). Kaktovik subsistence: Land use values through time in the Arctic National Wildlife Refuge Area. U.S. Fish and Wildlife Service: Fairbanks, AK.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. (1993). FAO species identification guide, marine mammals of the world. Rome: United Nations Environment Programme, Food and Agriculture of the United Nations.

Jenness, D. (1957). Dawn in Arctic Alaska. University of Minnesota Press, Minneapolis.

Jensen, P.G., and L.E. Noel. (2002). Caribou distribution in the range of the Central Arctic Herd. Part A: Aerial surveys in the Milne Point Unit, Prudhoe Bay Oilfield, Badami, and Bullen Point to Staines River study areas, summer 2001." Chapter 2A in Arctic Coastal Plain caribou distribution, summer 2001, M. A. Cronin, ed. Unpublished report for BP Exloration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska. pp. 1-86.

Jensen, P.G., L.E. Noel, and W.B. Ballard. (2003). Caribou distribution n the Badami and Bullen Point to Staines River study areas, Alaska, summer 2002. Chapter 1 in Caribou distribution in the range of the Central Arctic Herd, summer 2002. Report for BP Exploration (Alaska) Inc., by LGL Alaska Research Associates, Inc. (LGL Report P662). 42 pp + appendices.

Johnson et al. 2001 was incorrectly cited. Please disregard.

Johnson, R. ND. Personal communication. ABR.

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., A.M. Wildman, J.P. Parrett, J.R. Rose, T. Obritschkewtitsch, and A.A. Stickney. (2009). Avian studies for the Alpine Satellite Development Project, 2008. Sixth annual report for ConocoPhillips Alaska, Inc., Anchorage, AK, and Anadarko Petroleum Corporation by ABR, Inc.—Environmental Research & Services, Fairbanks, AK. 68 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., B.E. Lawhead, J.R. Rose, M.D. Smith, A.A. Stickney, and A.M. Wildman. (1999b). 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., B.E. Lawhead, J.R. Rose, A.S. Stickney, and A.M. Wildman. (1997). Wildlife studies on the Colville River delta, Alaska, 1996. Fifth annual report for ARCO Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 139 pp.

Johnson, C.B., B.E. Lawhead, J.R. Rose, J.E. Roth, S.F. Schlentner, A.A. Stickney, and A.M. Wildman. (2000b). 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., J.P. Parrett, and P.E. Seiser. (2008). Spectacled eider monitoring at the CD-3 Development, 2007. Annual report for ConocoPhillips Alaska, Inc., Anchorage, AK, and Anadarko Petroleum Corporation by ABR, Inc.—Environmental Research & Services, Fairbanks, AK. 43 pp.

Johnson, C.B., J.R. Rose, J.E. Roth, S.F. Schlentner, A.A. Stickney, and A.M. Wildman. (2000a) Alpine avian monitoring program, 1999. Final report, prepared for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, AK, by ABR, Inc., Fairbanks, AK.

Johnson, C.B., J.P. Parrett, and P.E. Seiser. (2007). Spectacled eider monitoring at the CD-3 development, 2006. Final annual report, prepared for ConocoPhillips Alaska, Inc., Anchorage, AK and Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc.—Environmental Research and Services, Fairbanks, AK. 39 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., R.M. Burgess, B.E. Lawhead, J.A. Neville, J.P. Parrett, A.K. Prichard, J.R. Rose, A.A. Stickney, and A.M. Wildman. (2003). Alpine avian monitoring program, 2001. Fourth annual and synthesis report for ConocoPhillips Alaska, Inc., Anchorage, AK, and Anadarko Petroleum Corporation by ABR, Inc.—Environmental Research & Services, Fairbanks, AK. 194 pp.

Johnson, C.B., W.B. Lentz, J.R. Rose, A.A. Stickney, and A.M. Wildman. (1999a). 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, L.A. (1987). Management of northern gravel sites for successful reclamation: A review. Arctic and Alpine Research 19: 530-536.

Johnson, P.R., and C.M. Collins. (1980). Snow pads used in pipeline construction in Alaska, 1976: construction, use and breakup. CRREL Report . U.S. Army Cold Regions Research Engineering Laboratory, Hanover, New Hampshire. pp. 80-17

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. (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 in the natural history of an Arctic oil field, Truett, J.C., and S.R. Johnson, (Eds.), New York: Academic Press. pp. 233-257.

Johnson, S.R., and D.R. Herter. (1989). Birds of the Beaufort Sea. Anchorage, AK: BP Exploration (Alaska) Inc.

Johnson, S.R., and L.E. Noel. (1979). Temperature and predation effects on abundance and distribution of lesser snow geese in the Sagavanirktok River Delta, Alaska. Waterbirds 28: 292-300.

Jones, B.M., C.D. Arp, M.T. Jorgenson, K.M. Hinkel, J.A. Schmutz, and P.L. Flint. (2009). Increase in the rate and uniformity of coastline erosion in Arctic Alaska. Geophysical Research Letters 36 L03503.

Jones, P.D. and A. Moberg. (2003). Hemispheric and large-scale surface air temperature variations: An extensive revision and an update to 2001. Journal of Climate 16: 206-223.

Jones, R.R. (2005). Daily heterogeneity in habitat selection by the porcupine caribou herd during calving. M.S. Thesis. University of Alaska, Fairbanks, AK. 91 pp.

Jones, S.H. and C.B. Fahl. (1994). Magnitude and frequency of floods in Alaska and conterminous basins of Canada, Water Resources Investigations Report 93-4179. Anchorage, AK: U.S. Geological Survey.

Jorgensen and Cater 1990 was incorrectly cited. Please see Jorgensen and Cater 1991 for correct reference.

Jorgensen et al. 1990 was incorrectly cited. Please see Jorgensen et al. 1991 for correct reference.

Jorgensen, M.T., J.E. Roth, M. Emers, S. Schlentner, and J. Mitchell. (2003). Assessment of ecological impacts associated with seismic exploration near the Colville Delta, Alaska. Abstract from Conference on Reducing the Effects of Oil and Gas Exploration and Procution on Alaska's North Slope: Issues, Practices, Technologies. Idaho National Engineering and Environmental Laboratory, Department of Energy.

Jorgenson, M.T., and M.R. Joyce. (1994). Six strategies for rehabilitating land distributed by oil development by oil development in Arctic Alaska. Arctic 47: 374-391.

Jorgenson, M.T., and T.C. Cater. (1991). Land rehabilitation studies in the Kuparuk Oilfield, Alaska, 1990. Report by Alaska Biological Research, Inc. to ARCO Alaska, Inc., Anchorage, AK. 51 pp.

Jorgenson, M.T., J.G. Kidd, and T.C. Cater. (1991). Rehabilitation of a thick gravel pad using snow capture and topsoil addition, Drill Site 13, Prudhoe Bay oilfield, Alaska, 1990. First annuual report by Alaska Biological Research, Inc., to ARCO Alaska, Inc., Anchorage, AK. 29 pp.

Kaleak, J. (1996). History of whaling by Kaktovik Village. In: Proceedings of the 1995 Arctic Synthesis Meeting, OCS Study MMC 95-0065. Anchorage, AK: U.S. Department of Interior, Minerals Management Service, Alaska OCS Region.

Kalxdorff, S.B. (1997). Collection of local knowledge regarding polar bear habitat use in Alaska. U.S. Fish and Wildlife Service, Technical Report MMM 97-2, Marine Mammals Management, Anchorage, AK.

Kalxdorff, S.S., Schliebe, T. Evans, and K. Proffitt. (2002). Aerial survey of polar bears along the coast and barrier islands of the Beaufort Sea, Alaska, September-October 2001. Anchorage, Alaska: U.S. Fish and Wildlife Service and LGL Alaska Research Associates, Inc.

Kancewick, M., and E. Smith. (1991). Subsistence in Alaska: towards a native priority. UMKC Law Review 59 No.3: 645-677.

Kane, D., S. Berezovskaya, K. Irving, R. Busey, M. Chambers, A. Blackburn, and M.R. Lilly. (2006). Snow survey data for the Sagavanirktok River/Bullen Point hydrology study: Spring 2006, Report INE/WERC 06-03. Fairbanks, AK: University of Alaska Fairbanks, Water and Environmental Research Center.

Kaplan, L. (1996). University of Alaska Fairbanks Alaska Native Language Center, Personal Communication.

Kaufman, D.S., D.P. Schneider, N.P. McKay, C.M. Ammann, R.S. Bradley, K.R. Briffa, G.H. Miller, B.L. Otto-Bliesner, J.T. Overpeck, and B.M. Vinther. (2009). Recent warming reduces long-term arctic cooling. Science 325: 1236-1239.

Kelly, B.P. (1988). Bearded seal, *Erignathus barbatus.* In: J.W. Lentfer (Ed.), Selected marine mammals of Alaska; Species accounts with research and management recommendations. Washington, DC: Marine Mammal Commission.

Kelso, D. (1981). Technical Overview of the State's Subsistence Program, Technical Paper Series. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Kelso, D. (1982). Subsistence use of fish and game resources in Alaska: Considerations in forming effective management policies, Technical Paper Series. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Kendall, S. (2005). Survey of breeding birds on Barrier Islands in the Arctic National Wildlife Refuge, 2003-2004. Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, AK.

Kendall, S. (2006). Distribution and abundance of post-breeding snow geese on the coastal plain of the Arctic National Wildlife Refuge, Alaska, 2003-2004. Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska.

Kendall, S., and A. Brackney. (2004). Nest Ecology for tundra nesting birds at the Canning River Delta, Arctic National Wildlife Refuge, Alaska, June-July 2003. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

Kendall, S., and C. Villa. (2005). Nest ecology for tundra nesting birds at the Canning River Delta, Arctic National Wildlife Refuge, Alaska, June-July 2004. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

Kendall, S., and C. Villa. (2006). Nest ecology for tundra nesting birds at the Canning River Delta, Arctic National Wildlife Refuge, Alaska, June-July 2005. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

Kendall, S., C. Villa, and J. Leibezeit. (2007). Nest ecology for tundra nesting birds at the Canning River Delta, Arctic National Wildlife Refuge, Alaska, June-July 2006. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

Kendall, S., D. Payer, and C. Buchholtz. (2003). Nest ecology for tundra-nesting birds at the canning river delta, Arctic National Wildlife Refuge, Alaska. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

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.

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. pp. 50.

Kertell, K. (2000). Pacific loon. Chapter 9 in The Natural History of an Arctic Oil Field, J. C. Truett and S. R. Johnson, (Eds.). New York: Academic Press. pp. 181-195.

Kertell, K. and R. Howard. (1992). Secondary productivity of impounded wetlands in the Prudhoe Bay oilfield: Implications for waterbirds. BP Exploration (Alaska), Environmental and Regulatory Affairs Department.

Kessel, B., and D.D. Gibson. (1978). Status and distribution of Alaska birds. In: Studies in Avian Biology 1. Lawrence, KS: Cooper Ornithological Society. Allen Press.

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.

King, J.E. (1983). Seals of the world, 2nd ed. Oxford: Oxford University Press; London: British Museum (Natural History); and New York: Comstock Publishing Associates.

Kinnetic Laboratories, Inc. (KLI). (1983). Meteorological and oceanographic data. Oceanographic Engineering Services, Point Thomson Development Project.

Kisautaq-Okakok, L. (1981). Puiguitkaat. North Slope Borough Commission on History and Culture. The 1978 Elder's Conference.

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.

Kogl, D.R., and D. Schell. (1974). Colville River delta fisheries research. Pages 483-504 in Environmental Studies of an Arctic Estuarine System. Final Report. U.S. Environmental Protection Agency Ecological Research series EPA-660/3-75-026.

Koughan, F.M. (1931). The Development of the reindeer industry in Alaska, 1890-1929. M.A. thesis, Department of Economics, University of California (Berkeley).

Kruse, J., J. Kleinfeld, and R. Travis. (1981). Energy development and the North Slope Inupiat: Quantitative analysis of social and economic change, man in the Arctic monograph No. 1, ISER report series No. 49. Anchorage, AK: University of Alaska, Institute of Social and Economic Research.

Kruse, J.A. (1982). Subsistence and the North Slope Inupiat: The effects of energy development, man in the Arctic monograph No. 4, ISER Report Series No. 56. Anchorage, AK: University of Alaska, Institute of Social and Economic Research.

Kruse, J.A. (1991). Alaska Inupiat Subsistence and Wage Employment Patterns: Understanding Individual Choice. Human Organization. Vol. 50, No. 4.

Kunz, M. and R. Reanier. (1994). Paleoindians in Beringia: evidence from arctic Alaska. Science 263: 660-662.

Kushlan, J.A., M.J. Steinkamp, K.C. Parsons, J. Capp., M.A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R.M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J.E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. (2002). Conservation for the Americas: the North American waterbird conservation plan, Version 1. Arlington, Virginia: Waterbird conservation for the Americas.

Lachenbruch, A.H. (1962). Mechanics of thermal contraction cracks and ice-wedge polygons in permafrost, GSA Special Paper 70. Geological Society of America.

Lanctot, R.B., J. Reed, D. Lacroix, P. Flint, J.C. Franson, T. Hollmén, M.D. Howell, and J.B. Grand. (2001). Monitoring Beaufort Sea waterfowl and marine birds, 2001 Annual Progress Report. Report prepared for Minerals Management Service, Anchorage, AK, by U. S. Geological Survey, Anchorage, AK.

Langdon, S., and R. Worl. (1981). Distribution and exchange of subsistence resources in Alaska. Prepared for the Alaska Department of Fish and Game. Anchorage, AK: University of Alaska, Arctic Environmental Information and Data Center.

Lapedes, D.N., (Ed.) (1976). McGraw-Hill dictionary of scientific and technical terms: New York, McGraw-Hill Book Company. 1634 pp.

Larned, W., R. Stehn, and R. Platte. (2003b). Eider breeding population survey, Arctic Coastal Plain, Alaska, 2003. Anchorage, AK: U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

Larned, W., R. Stehn, and R. Platte. (2005). Eider breeding population survey, Arctic Coastal Plain, Alaska, 2004. Survey prepared for U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, Soldotna and Anchorage, AK.

Larned, W., R. Stehn, and R. Platte. (2006). Eider breeding population survey, Arctic Coastal Plain, Alaska, 2006. U.S. Fish and Wildlife Service, Migratory Bird Management–Waterfowl Management Branch, Soldotna. AK, 53 pp.

Larned, W., R.M. Platte and R.S. Stehn. (2009). Waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2008. Unpublished report, Anchorage, AK: U.S. Fish and Wildlife Service.

Larned, W., R.M. Platte, and R.S. Stehn. (2001a). Eider breeding population survey, Arctic Coastal Plain, Alaska, 1999-2000. Anchorage, AK: U.S. Fish and Wildlife Service, Migratory Bird Management, and Ecological Services.

Larned, W., R.S. Stehn, J. Fischer, and R.M. Platte. (2001b). Eider breeding population survey, Arctic Coastal Plain, Alaska, 2001. Unpublished report by U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

Larned, W., R.S. Stehn, and R.M. Platte. (2003a) Eider breeding population survey, Arctic Coastal Plain, Alaska, 2002. Anchorage, AK: U. S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

Larned, W., R.S. Stehn, and R.M. Platte. (2007). Waterfowl breeding population survey. Arctic Coastal Plain, Alaska. U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, Soldotna and Anchorage, AK.

Larned, W., R.S. Stehn, and R.M. Platte. (2008). Waterfowl breeding population survey. Arctic Coastal Plain, Alaska. Soldotna and Anchorage, AK: U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch.

Lawhead, B.E., A.K. Prichard, M.J. Macander, and M. Emers. (2004). Caribou mitigation monitoring study for the Meltwater Project, 2003. Third annual report prepared for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 104 pp.

Lawhead, B.E. (1988). Distribution and movements of Central Arctic Herd caribou during the calving and insect seasons. In: Reproduction and calf survival. Proc. 3rd North American Caribou Workshop, 4-6 November 1987, Chena Hot Springs, AK. Alaska Dept. Fish and Game, Juneau. Wildlife Tech. Bull. No. 8. pp. 8-13.

Lawhead, B.E., A.K. Prichard, and M.J. Macander. (2009). Caribou monitoring study for the Alpine Satellite Development Program, 2008. Fourth annual report prepared for ConocoPhillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks. 91 pp.

Lawhead, B.E., and C.B. Johnson. (2000). Surveys of caribou and muskoxen in the Kuparuk–Colville region, Alaska, 1999, with a summary of caribou calving distribution since 1993. Final report prepared for Phillips Alaska, Inc. and Kuparuk River Unit, Anchorage, by ABR, Inc., Fairbanks, AK. 30 pp.

Lawhead, B.E., and D.A. Flint. (1993). Caribou movements in the vicinity of the planned Drill Site 3-T facilities, Kuparuk Oilfield, Alaska, 1991-92. Progress report prepared for ARCO Alaska, Inc., and the Kuparuk River Unit, Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 62 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. In 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, 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 Dept. Fish and Game. 59 pp.

Lawhead, B.E., J.P. Parrett, A.K. Prichard, and D.A. Yokel. (2006). A literature review and synthesis on the effect of pipeline height on caribou crossing success. BLM Alaska Open File Report 106. U.S. Department of the Interior, Bureau of Land Management, Fairbanks. 96 pp.

Lawhead, B.E., L.C. Byrne, and C.B. Johnson. (1993). Caribou synthesis, 1987-1990. In: 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.

Lawson, D.E. (1986). Response of permafrost terrain to disturbance: a synthesis of observations from northern Alaska, USA. Arctic and Alpine Research 18: 1-17.

Lee, S.H., D.M. Schell, T.L. McDonald, and W.J. Richardson. (2005). Regional and seasonal feeding by bowhead whales *Balaena mysticetus* as indicated by stable isotope ratios. Marine Ecology, Progress Series 285: 271-287.

Leffingwell, E.K. (1919). The geology of the Canning River region, Alaska. U.S. Geologic Survey Professional Paper 109: 1-251.

Lenart 2001 was incorrectly cited. Please disregard.

Lenart, E. A. (2007a). Units 25A, 25B, 25D, and 26C Porcupine Caribou Herd (PCH). In: Caribou management report of survey and inventory activities 1 July 2004-30 June 2006, P. Harper, (Ed.). Juneau: Alaska Department of Fish and Game. Project 3.0. pp 1-14; 232-248.

Lenart, E.A. (2007b). GMU 26B and 26C, Central Arctic Herd. In: Caribou management report of survey and inventory activities, 1 July 2004-30 June 2006, P. Harper, (ed.). Juneau: Alaska Department of Fish and Game, Division of Wildlife Conservation. pp. 1-16; pp. 284-308.

Lenart, E.A. (2007c). Units 25A, 25B, 25D, 26B, and 26C brown bear. In: Brown bear management report of survey and inventory activities 1 July 2004-30 June 2006, P. Harper, (ed.). Juneau: Alaska Department of Fish and Game. Project 4.0. pp. 1-10; pp. 300-311.

Lenart, E.A. (2008a). Units 26B and 26C moose. In: Moose management report of survey and inventory activities 1 July 2005-30 June 2007, P. Harper, (ed.). Juneau: Alaska Department of Fish and Game. Project 1.0. pp. 1-14.

Lenart, E.A. (2009a). Central Arctic herd, units 26b and 26C. In: Caribou management report of survey and inventory activities, 1 July 2006-30 June 2008. P. Harper, (Ed.), Juneau, AK: Alaska Department of Fish and Game, Division of Wildlife Conservation. Project 3.0.

Lentfer, J.W. (1972). Polar bear sea-ice relationships. International Conference on Bear Research and Management 2: 165-171.

Lentfer, J. W. (1975). Polar bear denning on drifting sea ice. Journal of Mammalogy 56: 716-718.

Lentfer, J.W., and R.J. Hensel. (1980). Alaska polar bear denning. In: Bears-their biology and management, C. J. Martinka and K. L. McArthur, (Eds.) Fourth International Conference on Bear Research and Management. Kalispell, Montana: Bear Biology Association Conference Ser. No. 4: 101-108.

Lettenmaier, D., D. Major, L. Poff, and S. Running. (2008). Water Resources. In: The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States, synthesis and assessment Product 4.3; A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC: U.S. Department of Agriculture. pp. 121-150.

Lewis, C.E. (1978). The subsistence lifestyle in Alaska, special publication 1. Fairbanks, AK: University of Alaska, School of Agriculture and Land Resources Management Seminar Series.

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 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. (1993b). 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). 1998 Aerial surveys of molting waterfowl in the Barrier Island-Lagoon system between the Stockton Islands and Flaxman Island, Alaska.

LGL Alaska Research Associates, Inc. (2000b). 1999 Point Thomson Unit nearshore marine fish study. Marine fish survey conducted in Lions Bay.

LGL Alaska Research Associates, Inc., and 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, Various pages.

LGL and Greeneridge. (1996). 1995 Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the central Alaskan Beaufort Sea. Northstar marine mammal monitoring program. LGL Report 2101-2. Report 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. (2001). Monitoring of industrial sounds, seals, and whale calls during construction of BP's Northstar Oil Development, Alaska Beaufort Sea, 2000. Draft Report by LGL Ltd., King City, ON, 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 and Woodward-Clyde Consultants. (1996). The 1995 Fish and oceanography study in Mikkelsen Bay, Alaska. Report to BP Exploration (Alaska) Inc., Anchorage, AK. pp. 102 + appendices.

Libbey, D. (1981). Cultural resource site identification. In: Cultural Resources in the mid-Beaufort Sea Region. Barrow, Alaska: North Slope Borough.

Libbey, D. (1983). Kaktovik area cultural resource survey: a preliminary report. Compiled by David Libbey for North Slope Borough Planning Department and State Historic Preservation Officer, Office of History and Archaeology, Alaska Division of Parks.

Libbey, D., G. Spearman, and D. Hoffman. (1979). Nuiqsut subsistence in native livelihood & dependence: A study of land use values through time, National Petroleum Reserve in Alaska work group 1 in cooperation with the North Slope Borough, Field Study 1. Anchorage, AK: U.S. Department of the Interior.

Liebezeit, J.R., S.J. Kendall, S. Brown, C.B. Johnson, P. Martin, T.L. McDonald, D.C. Payer, C.L. Rea, B. Streever, A.M. Wildman, and S. Zack. (2009). Influence of human development and predators on nest survival of tundra birds, Arctic Coastal Plain, Alaska. Ecological Applications 19: 1628-1644.

Limpert, R.J., and S.L. Earnst. (1994). Tundra swan (*Cygnus columbianus*). In: The birds of North America, No. 89, A. Poole and F. Gill, (Eds.) Philadelphia, PA: The Birds of North America, Inc.

Linnell, J.D.C., J.E. Swenson, R. Andersen, and B. Barnes. (2000). How vulnerable are denning bears to disturbance? Wildlife Society Bulletin 28: 400-413.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. (1984). Aerial surveys of endangered whales in the Northern Bering, Eastern Chukchi, and Alaskan Beaufort Seas, 1983: With a five year review, 1979-1983, Technical Report 955. San Diego, CA: Naval Ocean Systems Center for Minerals Management Service, Anchorage, AK.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. (1986). Seasonal patterns of distribution, abundance, migration and behavior of the Western Arctic Stock of Bowhead Whales (*Balaena mysticetus*) in Alaskan Seas. Report of the International Whaling Commission, Special Issue 8: 177-205.

Ljungblad, D.K., S.E. Moore, J.T. Clarke and J.C. Bennett. (1987). Distribution, abundance, behavior and bioacoustics of endangered whales in the Alaskan Beaufort and Eastern Chukchi Seas, 1979-1986, Technical Report 1177; OCS Study, MMS 87-0039. San Diego, CA: Naval Oceans Systems Center for Minerals Management Service, Anchorage, AK.

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, AK.

Lobdell, J. (1981). The Putuligayuk River Delta overlook site: Fragile traces of ancient man at Prudhoe Bay, Beaufort Sea , Alaska . ARCO Alaska, Inc., Anchorage, AK.

Lobdell, J. (1986). The Kuparuk Pingo site: A northern Archaic hunting camp of the Arctic Coastal Plain, North Alaska . Arctic 39 No. 1: pp. 47-51.

Lobdell, J. (1992a). Yukon Gold exploration wells archaeological and cultural resources reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage, AK.

Lobdell, J. (1992b). West Staines and South Staines exploration wells archaeological and cultural resources reconnaissance, North Slope, Alaska. Chevron U.S.A., Inc., Houston, TX.

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, AK.

Lobdell, J. (1997a). 1997 BPXA exploration program archaeological and cultural resources reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage, AK.

Lobdell, J. (1997b). 1996 Sourdough exploration well sites archaeological and cultural resources reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage, AK.

Lobdell, J. (1998). PTAC 1998/99 exploration and appraisal well sites archaeological and cultural resources reconnaissance, North Slope, Alaska. BP Exploration (Alaska) Inc., Anchorage, AK.

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.

Lobdell, J., R. Reanier and K. Wenzel, (2000). Archaeological testing at Jack’s Last Pingo (49-XBP-044), Jones Mound, Arctic Alaska. BP Exploration (Alaska) Inc., Anchorage.

Lobdell, J., R. Reanier and K. Wenzel, 2000. Archaeological Testing at Jack’s Last Pingo (49-XBP-044), Jones Mound, Arctic Alaska. BP Exploration (Alaska) Inc., Anchorage.

Loescher, R. (1997). Native subsistence rights – Where do we stand now in state and national politics? Sealaska Corporation, Volume 1999.

Long, F. Jr. (1996). History of subsistence whaling by Nuiqsut In: Proceedings of the 1995 Arctic synthesis meeting. OCS Study MMS 95-0065, pp. 73-76. United States Department of the Interior, Minerals Management Service, Alaska OCS Region: Anchorage, AK.

Lonner, T.D. (1980). Subsistence as an economic system in Alaska: Theoretical and policy implications. Technical Paper Series, Alaska Department of Fish and Game, Division of Subsistence. Anchorage, AK.

Loughlin, T.R. (1994). Marine mammals and the Exxon Valdez. San Diego, CA. Academic. 395 pp.

Lowry, L. (2001). Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic ocean. Arctic 54(3):237-243.

Lowry, L.F. (1993). Foods and feeding ecology. In: Burns, J.J., J.J. Montague, and C.J. Cowles, (Eds.). The Bowhead Whale, *Balaena mysticetus*, Special Publication 2. Lawrence, KS: Society for Marine Mammalogy.

Lowry, L.F., K.J. Frost, R. Davis, D.P. DeMaster and R.S. Suydam. (1998). Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biology 19: 221-230.

MacDonald, S.O., and J.A. Cook. (2009). Recent mammals of Alaska. Fairbanks: University of Alaska Press. 387 pp.

MacGillivray, A.O., D.E. Hannay, R.G. Racca, C.J. Perham, S.A. MacLean, and M.T. Williams. (2003). Assessment of industrial sounds and vibrations received in artificial polar bear dens, Flaxman Island, Alaska. Report to ExxonMobil Production Co. by JASCO Research Ltd., Victoria, BC, and LGL Alaska Research Associates, Inc., Anchorage, AK. 60 pp.

MacLean, E.A. (1980). Iñupiallu Tanŋiḷḷu Uqaluŋisa Iḷaŋich - Abridged Iñupiaq and English Dictionary. Fairbanks, AK: Alaska Native Language Center, University of Alaska.

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. Canada Wildlife Service Report Series 8. pp. 52.

Maher, W.J. (1960). Recent records of the California gray whale (*Eschrichtius glaucus*) along the north coast of Alaska. Arctic 13: 257-265.

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. Washington, D.C.: National Academy Press.

Mallek, E.J. (2001). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2000. Unpublished report. Fairbanks, AK: U. S. Fish and Wildlife Service.

Mallek, E.J., and R.J. King. (2000). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 1999. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service.

Mallek, E.J., R. Platte, and R. Stehn. (2003). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2002. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service, Waterfowl Management.

Mallek, E.J., R. Platte, and R. Stehn. (2004). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2003. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service.

Mallek, E.J., R. Platte, and R. Stehn. (2005). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2004. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service.

Mallek, E.J., R. Platte, and R. Stehn. (2006a). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2005. Unpublished report. Fairbanks, AK: U. S. Fish and Wildlife Service.

Mallek, E.J., R. Platte, and R. Stehn. (2006b). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2006. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service.

Mallek, E.J., R.J. King, and R.Stehn. (2002). Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska, 2001. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service.

Mannering, F., W. Kilareski and S. Washburn. (2005). Principles of highway engineering and traffic analysis. John Wiley and Sons, New York, NY. Third edition, 384 p.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. (1997). A pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78: 1069-1079.

Martin, P.D. (1997). Predators and scavengers attracted to locales of human activity. In: NPR-A Symposium Proceedings. OCS Study MMS 97-0013. Anchorage, Alaska: U.S. Department of the Interior, Minerals Management Service. pp. 6-24

Martin, P.D., and C.S. Moitoret. (1981). Bird populations and habitat use, Canning River Delta, Alaska. Unpublished report. Fairbanks, AK: U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge.

Martin, PD., J.L. Jenkins, F.J. Adams, M.T. Jorgenson, A.C. Matz, D.C. Payer, P. E. Reynolds, A.C. Tidwell, and J.R. Zelenak. (2009). Wildlife response to environmental arctic change. Report from the Wildlife response to environmental Arctic change (WildREACH): Predicting Future Habitats of Arctic Alaska Workshop. 17-18 November 2008, Fairbanks, Alaska. U.S. Fish and Wildlife Service, Fairbanks, AK. 138 pp.

Mauritzen, M., S.E. Belikov, A.N. Boltunov, A.E. Derocher, E. Hansen, R.A. Ims, O. Wiig, and N. Yoccoz. (2003). Functional responses in polar bear habitat selection. Oikos 100: 112-124.

McDowell Group. (2008). Information Insights and the McDowell Group, The role of the oil and gas industry in Alaska’s economy.

McElderry, H.I., and P.C. Craig. (1981). A fish survey in the lower Colville River drainage with an analysis of spawning use by Arctic cisco. Appendix 2 In: Environmental assessment of the Alaskan Continental Shelf, final report of principal investigators. Volume 7. U.S. Department of Interior, Bureau of Land Management, and U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program, Boulder, Colorado.

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.

McKendrick, S., R. Rodrigues, and S. Johnson. (2008). Howe Island snow goose and brant nest monitoring, Sagavanirktok River Delta Area, Alaska, 2008. Report for BP Exploration (Alaska), Inc. by LGL Alaska Research Associates, Inc., Anchorage, AK. 14 pp.

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.

McPhail, J.D. and C.C. Lindsey. (1970). The freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada Bulletin 173. pp. 381.

Michael Baker Jr., Inc. (1998). 1998 Spring break-up and hydrologic assessment, sourdough area development project, North Slope, Alaska. Prepared for: BP Exploration (Alaska), Inc., Anchorage, AK.

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 Report 6509; OCS Study MMS 87-0084. Report from BBN Labs Inc., Cambridge, MA, and LGL Ltd., King City, Ontario, Canada, for U.S. Minerals Management Service, Anchorage, AK. pp. 341. NTIS PB88-158498.

Miller R.V., J.H. Johnson, and N.V. Doroshenko. (1985). Gray whales (*Eschrichtius robustus*) in the Western Chukchi and East Siberian Seas. Arctic 38: 58-60.

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. In Canadian Wildlife Service Occasional Papers No. 40. Ottawa, Ontario, Canada: L Canadian Wildlife Service. 90 pp.

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton and W.J. Richardson. (1999). Whales. In: W. John Richardson (Ed.), Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-water Seismic Program in the Alaskan Beaufort Sea, 1998, LGL Report TA2230-3. Report from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD.

Miller, M. (1935). The great trek: the story of the five-year drive of a reindeer herd through the icy wastes of Alaska and northwestern Canada. Doubleday Doran & Co.: Garden City NY.

Miller, S. (2009). Spotlight species action plan: Polar bear [draft]. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, AK. 10 pp.

Miller, S., S. Schliebe, and K. Proffitt. (2006). Demographics and behavior of polar bears feeding on bowhead whale carcasses at Barter and Cross Islands, Alaska, 2002-2004. OCS Study MMS 2006-14 final report to Minerals Management Service, Alaska OCS Region, by U.S. Fish and Wildlife Service, Anchorage, AK. 29 pp.

Miller, S.D., G.C. White, R.A. Sellers, H.V. Reynolds, J.W. Schoen, K. Titus, V.G. Barnes, Jr., R.B. Smith, R.R. Nelson, W.B. Ballard, and C.C. Schwartz. (1997). Brown and black bear density estimation in Alaska using radiotelemetry and replicated mark-resight techniques. Wildlife Monographs 133.

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). Alaska outer continental shelf, Beaufort Sea planning area oil and gas lease sale 124, final environmental impact statement, OCS EIS/EA MMS 90-0063. U.S. Departmet of Interior, Minerals Management Service, Alaska OCS Region.

MMS. (1992). Migration and oil industry employment of North Slope Alaska Natives, social and economic studies. Technical Report No. 158. OCS Study, MMS 92-0061. January, 1993.

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 the Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. (2000a). Estimation of oil spill risk from Alaska North Slope, Trans-Alaska Pipeline, and Arctic Canada oil spill data sets. OCS Study MMS 2000-007. 113 pp.

MMS. (2001). Liberty development and production plan. Draft environmental impact statement, Vols. 1, 2, and 3.

MMS. (2002). Liberty development & production plan. Final environmental impact statement. MMS OCS EIS/EA MMS 200-020. U.S. Dept. of the Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS. (2003). Beaufort Sea planning area oil and gas - lease sales 186, 195, and 202. Final environmental impact statement. MMS OCS EIS/EA MMS 2003-001. U.S. Dept. of Interior, MMS, Alaska Outer Continental Shelf Region, Anchorage, AK.

MMS 2005 was cited incorrectly. Please disregard.

MMS. (2007a). Liberty development and production plan, ultra extended reach drilling from Endicott - satellite drilling island (SDI), environmental assessment, OCS EIS/EA, MMS 2007-054. Anchorage, AK: U.S. Department of Interior, Minerals Management Service, Alaska OCS Region.

MMS. (2008). Beaufort Sea and Chukchi Sea planning areas – oil and gas lease sales 209, 212, 217 and 221, draft environmental impact statement. OCS EIS/EA MMS 2008-0055. Anchorage, AK:USDOI, MMS, Alaska OCS Region.

MJM Research, LLC, Alaska Department of Natural Resources, ABR Environmental Research and Services, Inc., and Bureau of Land Management. (2007). Surveys of fish habitats in the Teshekpuk Lake region, 2003-2005. Prepared for the North Slope Borough, Barrow, AK. 125 pp.

Mohlman. (1996). Personal communication.

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, AK.

Monda, M.J., J.T. Ratti, and T.R. McCabe. (1994). Reproductive ecology of tundra swans on the Arctic National Wildlife Refuge, Alaska. Journal of Wildlife Management 58: 757-773.

Monnett, C., and J.S. Gleason. (2006). Observations of mortality associated with extended open-water swimming by polar bears in the Alaskan Beaufort Sea. Polar Biology 29: 681-687.

Montgomery W. (1998). Liberty Island route water/sediment sampling, 18-19 March 1998. Anchorage, AK: BPXA.

Montgomery, W. (1997). Liberty Island route water/sediment sampling. Anchorage, AK: BPXA.

Moore, S.E. (2000). Variability of cetacean distribution and habitat selection in the Alaskan Arctic, Autumn 1982-91. Arctic 53: 448-460.

Moore, S.E. and R.R. Reeves. (1993). Distribution and Movement. In: Burns, J.J., J.J. Montague, and C.J. Cowles, (Eds.). The Bowhead Whale, *Balaena mysticetus*, Special Publication 2. Lawrence, KS: Society for Marine Mammalogy.

Moore, S.E., J.M. Grebmeier, and J.R. Davies. (2003). Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Canadian Journal of Zoology 81 No. 4: 734-742.

Moore, S.E., J.M. Waite, L.L. Mazzuca, and R.C. Hobbs. (2000). Mysticete whale abundance and observations of prey associations on the Central Bering Sea Shelf. Journal of Cetacean Research and Management 2: 227-234.

Moore, S.E., J.T. Clarke, and D.K. Ljungblad. (1989). Bowhead whale (*Balaena mysticetus*) Spatial and temporal distribution in the Central Beaufort Sea during late summer and early fall 1979-86. Report to the International Whaling Commission 39: 283-290.

Moore, S.E., K.M. Stafford, D.K, Mellinger, and J.A. Hildebrand. (2006). Listening for large whales in the offshore waters of Alaska. BioScience 56: 9-55.

Morales, J.C., B.G. Hanks, J.W. Bickham, J.N. Derr, and B.J. Gallaway. (1993). Allozyme analysis of population structure in Arctic cisco (*Coregonus autumnalis*) from the Beaufort Sea. Copeia pp. 863-867.

Morrow, J.E. (1980a). The freshwater fishes of Alaska. Alaska Northwest Pub. Co., Anchorage, Alaska. pp. 248.

Mould, E.D. (1977). Movement patterns of moose in the Colville River area, Alaska. Thesis, University of Alaska, Fairbanks. 82 pp.

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. pp. 60 + 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. pp. 58 + 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. pp. 59 + 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. pp. 60 + Append.

Moulton, L.L. (2001). Harvest estimate and associated information for the 2000 Colville River fall fishery. Report to Phillips Alaska, Inc. and BP Exploration (Alaska) inc., Anchorage, AK.

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. pp. 320 + 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. pp. 53 + Append.

Moulton, L.L., and B.T. Seavey. (2004). Harvest estimate and associated information for the 2003 Colville River fall fishery. Report by MJM Research for ConocoPhillips Alaska, Inc. 45 p. + 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. pp. 49 + 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. pp. 41 + 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. pp. 36 + Append.

Moulton, V.D., W.J. Richardson, R.E. Elliott, T.L. McDonald, C. Nations, and M.T. Williams. (2005). Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea. Marine Mammal Science 21 2: 217-242.

Moulton, V.D., M.T. Williams, W.J. Richardson, and T.L. McDonald. Estimated numbers of seals and whales potentially affected by Northstar activities, Nov. 2001 to Oct. 2002. In: Monitoring of Industrial Sounds, Seals, and Bowhead Whales near BP's Northstar Oil Development, Alaska Beaufort Sea, 1999-2002. LGL and Greeneridge Sciences Inc. May 2003.

Mowry, T. (2008). Why did the polar bear cross the Brooks Range? Biologists are baffled. Fairbanks Daily News-Miner, March.

Mull, C.G., and K.E. Adams (Eds.). (1989). Bedrock Geology of the Eastern Koyukuk Basin, Central Brooks Range, and East Central Arctic Slope Along the Dalton Highway, Yukon River to Prudhoe Bay, Alaska, Guidebook 7, Volume 1. Anchorage, AK: Alaska Division of Geological & Geophysical Surveys.

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; 107-109.

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.

Murphy, S.M., and B.E. Lawhead. (2000). Caribou. Chapter 4 in the natural history of an Arctic oil field: Development and the biota, J. Truett and S.R. Johnson, (Eds.) . San Diego, CA: Academic Press. pp. 59-84

Murphy, S.M., and J.A. Curatolo. (1987). Activity budgets and movement rates of caribou encountering pipelines, roads, and traffic in northern Alaska. Canadian Journal of Zoology 65: 2483-2490.

Murray, D.F., and R. Lipkin. (1987). Candidate threatened and endangered plants of Alaska with comments on other rare plants. Univ. of Alaska Museum, Fairbanks, AK. 76 pp.

Murray, D.F., and R. Lipkin. (1997). Alaska rare plant field guide. Washington, DC: U.S. Department of the Interior, Office of Equal Opportunity.

Myerchin, G.M., D.M. White, W.E. Schnabel, M.R. Lilly, K.M. Holland and P. Prokein. (2008). Lake survey data for the Coastal Plain from the Sagavanirktok River to Bullen Point: Spring 2008, Report INE/WERC 08.04. Fairbanks, AK: University of Alaska, Water and Environmental Research Center.

Myerchin, G.M., D.M. White., M.R. Lilly, K.M. Holland, and P. Prokein. (2007). Lake Survey Data for the Coastal Plain from the Sagavanirktok River to Bullen Point: Spring 2007, Report INE/WERC 07.14. Fairbanks, AK: University of Alaska Fairbanks, Water and Environmental Research Center.

Naiman, J. (1996). ANILCA Section 910: An undervalued protection for Alaskan villagers' subsistence. Fordnam Environmental Law Journal VII. pp. 211-350.

National Climate Data Center (NCDC). (2009). Climate data for the Deadhorse Airport. National Climate Data Center. Available online at: May be viewed at: http: //www.ncdc.noaa.gov/ oa/ncdc.html

National Marine Fisheries Service (NMFS). (1999). Essential fish habitat consultation guidance. Office of Habitat Conservation, National Marine Fisheries Service, Silver Spring, MD.

National Oceanic and Atmospheric Administration (NOAA). (2009). Tides and currents, extremes. Accessed 17 June 2009. Available online at: http://tidesandcurrents. noaa.gov.

National Research Council (NRC). (2003). Cumulative environmental effects of oil and gas activities on Alaska's North Slope. Washington, DC: National Academy Press.

National Resource Conservation Service. (NRCS). (2009). Alaska snow, water and climate services. Available online at: http: //www.ambcs.org/pub/sc_sum_ak/PRECIP.HTM

Nellmann, C., and P.E. Reynolds. (1997). Predicting late winter distribution of muskoxen using an index of terrain ruggedness. Arctic and Alpine Research 2: 334-338.

Nelson, R. (1979). Cultural values of the land in native livelihood and dependence: A study of land use values through time. North Slope Borough Contract Staff. National Petroleum Reserve in Alaska 105(C) Land Use Study, Field Study 1. USDOI, BLM, NPR-A Work Group 1. Anchorage, AK.

Nelson, T, T.C. Cannon, W.R. Olmstead, and K.C. Wiley. (1987). Surveys of commercial and domestic fisheries in the central and eastern Beaufort Sea. In: Endicott environmental monitoring program, Final Reports, 1985. Part VI, Volume 6. Report by Envirosphere Company for U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska. pp. 38.

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. Anchorage, AK: U.S. Fish and Wildlife Service, Alaska Investigations, Branch of Wetlands and Marine Ecology.

Nielson, J.M. (1977). Beaufort sea study – Historic and subsistence site inventory: A preliminary cultural resource assessment. North Slope Borough. Barrow, AK.

Nobmann, E.D. (1997). Nutritional benefits of subsistence foods. Report for University of Alaska Anchorage, Institute of Social and Economic Research, Anchorage, AK. PO087553. North Slope Borough.

Noel et al. 2000a was incorrectly cited. Please see Noel et al 2000 for correct reference.

Noel and King 2000c was incorrectly cited. Please disregard.

Noel, L. E., and J. C. King. (2000a). Large mammal distribution in the Badami Study Area, summer 1999. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates. Inc., Anchorage, AK.

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, AK, by LGL Alaska Research Associates, Anchorage, AK.

Noel, L.E., and E.E. Cunningham (2003). Caribou distribution in the Badami and Bullen Point to Staines River survey areas, Alaska, summer 2003. Report for BP Exploration (Alaska) Inc. by ENTRIX, Inc., Anchorage, AK.

Noel, L.E., and J.C. King. (2000b). 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 M.W. Demarchi. (2002). Caribou distribution in the Milne Point Unit study area, summer 2000. Report for BP Exploration (Alaska) Inc., Anchorage, by LGL Alaska Research Associates, Inc., Anchorage, AK. 52 pp.

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., and T.L. Olson. (1999d). 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. (1999e). 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 T.L. Olson. (2001). Bullen Point to Staines River large mammal distribution, summer 2000. Prepared by ENTRIX, Inc., for BP Exploration (Alaska) Inc., Anchorage, AK.

Noel, L.E., C.J. Perham, and S.R. Johnson. (1999b). 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., 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.

Noel, L.E., Johnson, S.R. and Wainwright, P.F. (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.

Noel, L.E., R. Rodrigues, and S R. Johnson. (2002b). Nesting status of the common eider in the central Beaufort Sea, summer 2001. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for BP Exploration (Alaska) Inc., Anchorage, AK.

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., 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.

Noel, L.E., S.R. Johnson, and R. Rodrigues. (2002a). Aerial surveys of molting waterfowl in the barrier island-lagoon systems between Spy Island and Brownlow Point, Alaska, 2000. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for BP Exploration (Alaska) Inc., Anchorage, AK. 69 pp.

Noel, L.E., S.R. Johnson, G.M. O'Doherty, and J.W. Helmericks. (2002c). The status of snow geese in the Sagavanirktok River delta area, Alaska: 2001 monitoring program. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for BP Exploration (Alaska) Inc., Anchorage, AK. 40 pp.

North Pacific Fishery Management Council (NPFMC). (2005). Final environmental impact statement (EIS) for essential fish habitat in Alaska. North Pacific Fishery Management Council, Anchorage, Alaska. 715 pp.

North Slope Borough (NSB). (1980). Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun: The traditional land use inventory for the Mid-Beaufort Sea, Volume 1. Barrow, AK: North Slope Borough Commission on History and Culture.

NSB. (1995). 1993-1994 Economic profile and census report Volume VII. George N. Ahmaogak, Sr. Mayor. North Slope Borough Department of Planning & Community Services, Barrow, AK.

NSB. (2003). Unpublished. Subsistence survey data. North Slope Borough, Division of Wildlife Management, Barrow, Alaska.

NSB. (2005). North Slope Borough comprehensive plan. Issues, goals, objectives, and policies. Adopted by the NSB Assembly under Ordinance 75-6-48 on 11 October 2005. Barrow, AK: NSB.

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. (1994) Yellow-billed loon (*Gavia adamsii*). The Birds of North America 121: 1-24.

North, M.R., and M.R. Ryan. (1988). Yellow-billed loon, *Gavia adamsii*, breeding chronology and reproductive success in arctic Alaska. Canadian Field-Nat. 102: 485-490.

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, AK. 18 pp.

Northern Economics, Inc. (1995). Socioeconomic impacts of changes in Alaska's petroleum royalty and tax system. Prepared for the Alaska Oil and Gas Policy Council. December, 1995.

Northern Economics, Inc. (2006). The North Slope economy, 1965-2006. OCS Study MMS 2006-020. Anchorage, AK: USDOI, MMS, Alaska OCS Region.

Norton, D.W., J. Brower, and B. Mayc. (1993). Checklist of birds, Barrow Alaska. Barrow, AK: Arctic Sivunmun Ilisagvik College.

Novitski, R.P., R.D. Smith, and J.D. Fretwell. (1997). Restoration, creation, and recovery of wetlands: wetland function, values, and assessment. U.S. Geological Survey national water summary on wetland resources. U.S.G.S. Water Supply Paper 2425. Accessed online 17 November 2009, last modified 20 October 1997. Available online at: http://water.usgs.gov/nwsum/WSP2425/functions.html

Oasis Environmental, Inc. (2009). Point Thomson project, environmental report—pre-application draft. Prepared by Oasis Environmental, Inc., for ExxonMobil Corporation, Anchorage, AK.

Obbard, M.E., T.L. McDonald, E.J. Howe, E.V. Regehr, and E.S. Richardson. (2007). Polar bear population status in southern Hudson Bay, Canada. U.S. Geological Survey administrative report, Alaska Science Center, Anchorage, AK. 32 pp.

Obritschkewitsch, T., P.D. Martin, and R.S. Suydam. (2001). Breeding biology of Steller's eiders nesting near Barrow, Alaska, 1999-2000. Technical Report, NAES-TR-01-04, by U.S. Fish and Wildlife Service, Fairbanks, AK, and North Slope Borough, Department of Wildlife Management, Barrow, AK. 113 pp.

O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost, and A.E. Dizon. (1997). Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Molecular Ecology 6: 955-970.

Olson, D.F. (1969). Alaska reindeer herdsmen: A study of native management in transition. Institute of Social, Economic and Government Research, University of Alaska: Fairbanks, AK.

Olson, J.E. (1982). Acid pollution and acid rain: Report 8, The effects of air pollution and acid rain.

Osterkamp, T.E. (2003). A thermal history of permafrost in Alaska. In: Phillips, Marcia, Sarah M. Springman, and Lukas U. Arenson (Eds.). Proceedings of the 8th International Conference on Permafrost, Lisse, The Netherlands: 21-25 July 2003. Zurich, Switzerland: A.A. Balkema. 2: 863-868.

Osterkamp, T.E. (2007). Characteristics of the recent warming of permafrost in Alaska. Journal of Geophysical Research 112, F02S02.

Ovendon, L. (1986). Hydroseral histories of the Old Crow peatlands, northern Yukon. Ph. D. Dissertation, Univ. of Toronto, Canada

Page, R.A., Biswas, N.N., Lahr, J.C., and Pulpan, H., (1991). Chapter 4, Seismicity of continental Alaska, in Slemmons, D.B., Engdahl, E.R., Zoback, M.D., and Blackwell, D.D. (eds.), Neotectonics of North America: Geological Society of America, Boulder, CO, Decade Map Volume 1.

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.

Pamperin, N.J., E.H. Follmann, and B. Petersen. (2006) Interspecific killing of an Arctic fox by a red fox at Prudhoe Bay, Alaska. Arctic 59, No. 4: 361-364.

Pamperin, N.J., E.H. Follmann, and B.T. Person. (2008). Sea-ice use by Arctic foxes in northern Alaska. Polar Biology 31: 1,241-1,426.

Parrett, L.S. (2007). Summer ecology of the Teshekpuk caribou herd. M.S. thesis, University of Alaska, Fairbanks, AK. 148 pp.

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. Vol. 59 (Nov. 1988). Anchorage, AK: USDOC, NOAA, OCSEAP, and USDOI, MMS, Alaska OCS Region. pp. 147-465.

Pedersen, S. (1989). Assessment of the 1988-89 Kaktovik subsistence fishery. Internal report, Alaska Department of Fish and Game, Division of Subsistence: Fairbanks.

Pedersen, S. (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 Social and Economic Studies Program Technical Report No. 160, J. A. Fall and C. J. Utermohle, (Eds.), Anchorage: Alaska OCS Region, Minerals Management Service.

Pedersen, S. and A. Linn, Jr. (2005). Kaktovik 2000-2002 subsistence fishery harvest assessment, final report for FIS Study 01-101 U.S. Fish and Wildlife Service Office of Subsistence Management Fisheries Management Program.

Pedersen, S., and M.W. Coffing. (1984). Caribou hunting: land use dimensions and recent harvest patterns in Kaktovik, Northeast Alaska. ADF&G Technical Paper No. 92.

Pedersen, S., and N.S. Shishido. (1988). Subsistence study at Nuiqsut. Report by Alaska Department of Fish and Game, Division of Subsistence Fisheries, Fairbanks, AK.

Pedersen, S., D. Libbey and W. Schneider. (1979). Barrow-Atqasuk (Atkasook) Synopsis. In Native Livelihood & Dependence: A Study of Land Use Values Through Time. U.S. Department of the Interior National Petroleum Reserve in Alaska 105(C) Field Study 1. Prepared by North Slope Borough Contract Staff for National Petroleum Reserve in Alaska Work Group 1: Anchorage.

Perham, C. J. (2009). Personal communication.

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.

Perham, C.J. (2001). Arctic fox den distribution and activity between the Sagavanirktok River and the Staines River, Alaska, summer 2000. Report for BP Exploration (Alaska) Inc. By LGL Alaska Research Associates, Inc., Anchorage, AK. 32 pp.

Perham, C.J. (2005). Proceedings: Beaufort Sea polar bear monitoring workshop, September 3-5, 2003, Anchorage, Alaska. OCS Study MMS 2005-034, prepared for Minerals Management Service, Alaska OCS Region, Anchorage, AK.

Person, B.T., A.K. Prichard, G.M. Carroll, D.A. Yokel, R.S. Suydam, and J.C. George. (2007). Distribution and movements of the Teshekpuk caribou herd, 1990-2005: prior to oil and gas development. Arctic 60: 238-250.

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. pp. 33.

Peterson, T.C. and R.S. Vose. (1997). An overview of the Global Historical Climatology Network temperature database. Bulletin of the American Meteorological Society 78: 2837-2849.

Pfalker, G., L.M. Gilpin, and J.C. Lahr. (1994). Plate 12, neotectonic map of Alaska: Geological Society of America, Geology of Alaska, Volume G-1 of the Geology of North America.

Pitelka, F.A. (1957). Some characteristics of microtine cycles in the Arctic. In: Arctic Biology: 18th Annual Colloquium, H.P. Hansen, (Ed.), pp. 73-88. 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.

PND 2009 was incorrectly cited. Please see PND 2009a for correct reference.

PND Engineers, Inc. (2009a). Point Thomson development 2009 spring break-up hydrology report – DRAFT. Prepared for ExxonMobil. Anchorage, AK.

PND Engineers, Inc. (2009b). Point Thomson coastal engineering assessment. Prepared for ExxonMobil. Anchorage, AK.

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.

Pollard, R.H., W.B. Ballard, M.A. Cronin, and L.E. Noel. (1996). Parasitic insect abundance and microclimate of gravel pads and tundra within the Prudhoe Bay oil field, Alaska, in relation to use by caribou, *Rangifer tarandus granti*. Canadian Field-Naturalist 110: 649-658.

Popov, L.A. (1976). Status of main ice forms of seals inhabiting waters of the U.S.S.R. and adjacent to the country marine areas, Report No. FAO-FI-ACMRR/MM/SC/51. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO), Fisheries Department; Bergen, Norway: Advisory Committee on Marine Resources Research, Scientific Consultation on Marine Mammals.

Post, E., M.C. Forchhammer, M.S. Bret-Harte, T.V. Callaghan, T.R. Christensen, B. Elberling, A.D. Fox, O. Gilg, D.S. Hik, T.T. Hoye, R.A. Ims, E. Jeppesen, D.R. Klein, J. Madsen, A.D. McGuire, S. Rysgaard, D.E. Schindler, I. Stirling, M.P. Tamstorf, N.J.C. Tyler, R. van der Wal, J. Welker, P.A. Wookey, N.M. Schmidt, and P. Aastrup. (2009). Ecological dynamics across the arctic associated with recent climate change. Science 325: 1355-1358.

Powell, A.N., and S. Backensto. (2009). Common ravens (*Corvus corax*) nesting on Alaska's North Slope oil fields. Final report to U.S. Department of the Interior, Minerals Management Service, Anchorage, AK, by University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Fairbanks, AK. OCS Study MMS 2009-007. 37 pp.

Pullman, E.R., and B.E. Lawhead. (2002). Snow depth under elevated pipelines in western North Slope oilfields. Final report prepared for Phillips Alaska, Inc., Anchorage, by ABR, Inc., Fairbanks, AK. 19 pp.

Quackenbush, L., R.H. Day, B.A. Anderson, F.A. Pitelka, B.J. McCaffrey. (2002a). Historical and present breeding season distribution of Steller's eiders in Alaska. School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Environmental Research & Services, Fairbanks, Alaska, University of California, Berkeley, California, Yukon Delta National Wildlife Refuge, Bethel, AK.

Quakenbush, L., and J. Cochrane. (1993). Report on the conservation status of the Steller's eider (*Polysticta stelleri*), a candidate threatened and endangered species. Unpubl. manuscript, by U.S. Fish and Wildlife Service, Ecological Services, Alaska. 26 pp.

Quakenbush, L., R. Suydam, and T. Obritschkewitsch. (2000). Habitat use by Steller's eiders during the breeding season near Barrow, Alaska, 1991-1996. Unpubl. report, by Univ. Alaska Fairbanks, North Slope Borough, and U.S. Fish and Wildlife Service, Fairbanks, AK. 45 pp.

Quakenbush, L., R. Suydam, T. Obritschkewitsch, and M. Deering. (2004). Breeding biology of Steller's eiders (*Polysticta stelleri*) near Barrow, Alaska, 1991-99. Arctic 57: 166-182.

Quakenbush, L., R.H. Day, B.A. Anderson, F.A. Pitelka, B.J. McCaffrey. (2002b). Historical and present breeding season distribution of steller's eiders in Alaska. Western Birds 33: 99-120.

Quakenbush, L.T., J.J. Citta, J.C. Craig, R. Smith, and M.P. Heide-Jorgensen. (2009). Fall movements of bowhead whales in the Chukchi Sea. Paper presented at the Alaska Marine Science Symposium, Anchorage, AK. pp. 19-23.

Quakenbush, L.T., R.S. Suydam, K.M. Fluetsch, and C.L. Donaldson. (1995). Breeding biology of Steller's eiders nesting near Barrow, Alaska, 1991-1994. Unpubl. Tech. Report NAES-TR-95-03, by U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, AK, and North Slope Borough, Dep. Wildl. Manage., Barrow, AK. 53 pp.

Quakenbush, L.T. (1988). Spotted seal, *Phoca largha*. J.W. Lentfer (Ed.), Selected Marine Mammals of Alaska; Species Accounts with Research and Management Recommendations. Washington, DC: Marine Mammal Commission.

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 Distribution of moose, sheep, muskox and furbearing mammals in northeastern Alaska, R. D. Jakimchuk, ed. 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, No. 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 the Interior, National Park Service, Anchorage, AK.

Rawlinson 1983 was incorrectly cited. Please see Rawlinson 1993 for correct citation.

Rawlinson, S.E. (1990). Surficial Geology and Morphology of the Alaskan Central Arctic Coastal Plain: Alaska Division of Geological & Geophysical Surveys Public Data File 90-27.

Rawlinson, S.E. (1993). Surficial Geology and Morphology of the Alaskan Central Arctic Coastal Plain: Alaska Division of Geological & Geophysical Surveys Report of Investigation 93-1.

Ray, D.J. (1983). Ethnohistory in the Arctic: the Bering Strait Eskimo. Limestone Press: Kingston (Ontario, Canada).

Reanier, R. (1995). The Antiquity of Paleo Indian Materials in northern Alaska. Arctic Anthropology 32: 31-50.

Reanier, R.E. (2007). Cultural resources reconnaissance for the Bullen Point road project, North Slope, Alaska , for the years 2005 and 2006. Report prepared for ADOTPF.

Reed, C.E. (1985). The role of wild resource use in communities of the central Kenai Peninsula and Kachemak Bay, Alaska, Technical Paper No. 106. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Reeves, R.R. (1980). Spitsbergen bowhead stock: A short review. Marine Fisheries Review 42: 65-69.

Regehr, E.V., C.M. Hunter, H. Caswell, S.C. Amstrup, and I. Stirling. (2007). Polar bears in the southern Beaufort Sea. Vol 1 of Survival and breeding in relation to sea ice conditions, 2001-2006. Anchorage, Alaska: U.S. Geological Survey administrative report, Alaska Science Center.

Regehr, E.V., S.C. Amstrup, and I. Stirling. (2006). Polar bear population status in the southern Beaufort Sea. U. S. Geological Survey, Alaska Science Center, Anchorage. Open-File Report 1337. 20 pp.

Reges, A.E., and J.A. Curatolo. (1985). Behavior of caribou encountering a simulated low-elevation pipeline. Final report prepared for ARCO Alaska, Inc., Anchorage, by Alaska Biological Research, Inc., Fairbanks, AK. 17 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. Unpublished report by Envirosphere Co. Available at U.S. Army Corps of Eng., Anchorage, AK. pp. 60.

Reynolds et al. 2006 was incorrectly cited. Please disregard.

Reynolds et al. 2004 unpublished report was incorrectly cited. Please see Reynolds et al. 2005 for correct reference.

Reynolds, H.V. (1979). Population biology, movements, distribution and habitat utilization of a grizzly bear population in NPR-A. In studies of selected wildlife and fish and their use of habitats on and adjacent to NPR-A 1977-1978. Vol. 1, pp. 129-182. NPR-A Work Group 3, Field Study 3, U. S. Department of the Interior, Anchorage, AK.

Reynolds, H.V., ADF&G, personal communication, 2003.

Reynolds, H.V., E.F. Becker, R.A. Strauch, and J.W. Burch. (2005). Application of a double-count line-transect method to estimate density of brown bears in arctic Alaska. Unpublished file report, Alaska Department of Fish and Game. 9 pp.

Reynolds, P.E. (1998). Dynamics and range expansion of a reestablished muskox population. Journal of Wildlife Management 62, No. 2: 734-744.

Reynolds, P.E. (2001). Reproductive patterns of female muskoxen in northeastern Alaska. Alces. 37, No. 2: 1-8.

Reynolds, P.E. (2006). Muskoxen in the Arctic National Wildlife Refuge Game Management Unit 26C, 2005-2006. Unpublished report for the United States Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, AK. 16 pp.

Reynolds, P.E. (2009). 2009 precalving census of muskoxen in the Arctic National Wildlife Refuge, Unit 26C. Unpublished report for the United States Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska. Unpublished report. 4 pp.

Reynolds, P.E., H.V. Reynolds, and R.A. Shideler. (2002a). Predation and multiple kills of muskoxen by grizzly bears. Ursus 13: 789-94.

Reynolds, P.E., K.J. Wilson, and D.R. Klein. (2002b). In Arctic Refuge coastal plain terrestrial wildlife research summaries, D.C. Douglas, P.E. Reynolds, and E.B. Rhodes, (Eds.), pp. 54–65. U.S. Geological Survey, Biological Resources Division, Biological Sciences Report USGS/BRD/BSR-2002-0001.

Reynolds, P.E., J.D. Herriges, and M.A. Masteller. (1986). Ecology of muskoxen in the Arctic National Wildlife Refuge, Alaska, 1982-1985. In Arctic National Wildlife Refuge coastal plain resource assessment: 1985 update report—Baseline study of the fish, wildlife, and their habitats, Vol. 2, G. W. Garner, and P. E. Reynolds, (Eds.), pp. 573-631. ANWR Progress Report No. FY86-2, U.S. Fish and Wildlife Service, Anchorage, AK.

Rich, T.D., C.J. Beardmore, H. Berlanga, P.J. Blancher, M.S.W. Bradstreet, G.S. Butcher, D.W. Demarest, E.H. Dunn, W.C. Hunter, E.E. Iñigo-Elias, J.A. Kennedy, A.M. Martell, A.O. Panjabi, D.N. Pashley, K.V. Rosenberg, C.M. Rustay, J.S. Wendt, and T.C. Will. (2009). Partners in flight North American landbird conservation plan, 2004. Version: March 2005.Cornell Lab of Ornithology, Ithaca, NY. Available online at: http://www.partnersinflight.org/cont_plan/.

Richard, P.R., A.R. Martin and J.R. Orr. (1997). Study of summer and fall movements and dive behaviour of Beaufort Sea belugas, using satellite telemetry: 1992-1995. ESRF Rep. 134. Environ. Stud. Res. Funds, Calgary, AB. 38 pp.

Richard, P.R., A.R. Martin, and J.R. Orr. (2001). Summer and autumn movements of belugas of the eastern Beaufort Sea Stock. Arctic 54 3: 223-236.

Richardson, W.J. and K.J. Finley. (1989). Comparison of behavior of bowhead whales of the Davis Strait and Bering/Beaufort stocks. Report from LGL Limited, King City, Ontario to MMS. NTIS No. PB89-195556. 131 pp.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme and D.H. Thomson. (1995). Marine mammals and noise. San Diego, CA: Academic Press.

Riehle, J.R., M.D. Fleming, B.F. Molnia, J.H. Dover, J.S. Kelley, M.L. Miller, W.J. Nokleberg, G. Plafker, and A.B. Till. (1996). Digital shaded-relief image of Alaska, Miscellaneous Investigations Series I-2585. U.S. Geological Survey.

Riemnitz, E. and D. Maurer. (1978). Storm surges on the Beaufort Sea shelf, open file report 78-593, U.S Department of the Interior, Geological Study. pp. 18.

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. (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. and ABR. ND. Personal communication.

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.

Ritchie, R.J., and J.G. King. (2000). Tundra swans. Chapter 10 in The Natural History of an Arctic Oil Field, Truett, J. C., and S. R. Johnson, (eds.), pp. 197-220. New York: Academic Press.

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., C.T. Schick, and J.E. Shook. (2003). Spectacled and Steller's eiders surveys and habitat mapping at U. S, Air Force Radar Sites in Northern Alaska, 2002. Unpublished report prepared for the U. S. Fish and Wildlife Service, Ecological Services, Fairbanks, AK, and U.S. Air Force, Elmendorf Air Force Base, AK by ABR, Inc.—Environmental Research and Services, Fairbanks, AK. 45 pp.

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., R.M. Burgess, J. Shook, and T. Obritschkewitsch. (2009). Surveys for nesting and brood-rearing brant and lesser snow geese, Barrow to Fish Creek Delta, and lesser snow goose banding near the Ikpikpuk River delta, Alaska, 2008. Annual report for North Slope Borough, Barrow, AK, by ABR, Inc.—Environmental Research and Services, Fairbanks, AK. 70 pp.

Ritchie, R.J., T. Doyle, and J. Wright. (1998). Peregrine falcons (*Falco peregrinus*) nest in a quarry and on highway cutbanks in Alaska. Raptor Research 32: 261-264.

Robbe 1996 was incorrectly cited. Please see Robbe 1995 for correct reference.

Robbe, G.A. (1995). Dalton Highway visitor survey results report. School of Agriculture and Land Resources Management, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. pp. 127. Prepared for the BLM and the ADOT&PF.

Robertson, D.G., A.W. Brackney, M.A. Spindler, and J.W. Hupp. (1997). Distribution of autumn-staging lesser snow geese on the northeast coastal plain of Alaska. Journal of Field Ornithology 68: 124-134.

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.

Rode, K.D., S.C. Amstrup, and E.V. Regehr. (2000). Reduced body size and cub recruitment in polar bears associated with sea ice decline. Ecological Applications.

Rode, K.D., S.C. Amstrup, and E.V. Regehr. (2007. Polar bears in the southern Beaufort Sea, III: Staure, mass, and cub recruitment in relationship to time and sea ice extent between 1982 and 2006. U.S. Geological Survey administrative report, Alaska Science Center, Anchorage, AK. 28 pp.

Rodrigues, R. (2002a). Nest density, nest survival, and habitat use of tundra-nesting birds, Point Thomson, Alaska 2002. Prepared for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc. Anchorage, AK.

Rodrigues, R. (2002b). Preliminary assessment of tundra-nesting birds in the Point Thomson area, Alaska, 2001. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for BP Exploration (Alaska) Inc., Anchorage, AK. 26 pp. + appendices.

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.

Rojek, N. (2008). Unpublished data.

Rosenberg, D.M., H.V. Danks, and D.M. Lehmkuhl. (1986). Importance of insects in environmental impact assessment. Environmental Management 6: 773-783.

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, AK. 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, AK. 67 pp.

Rugh, D.J. and Mark A. Fraker. (1981). Gray Whale (*Eschrichtius robustus*) Sightings in Eastern Beaufort Sea. Arctic 34: 86-187.

Rugh, D.J., K.E.W. Shelden, and D.E. Withrow. (1997). Spotted seals, *Phoca largha*, in Alaska, Marine Fisheries Review 59 No. 1: 1-18.

Rugh, D.J., K.E.W. Sheldon, D.D. Withrow, H.W. Braham, and R.P. Angliss. (1993). Spotted Seal (Phoca largha) Distribution and Abundance in Alaska, 1992. Silber Spring, MD: Annual Report to the MMPA Assessment Program, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

Rugh, David J., R.C. Hobbs, J.A. Lerczak, and J.M. Breiwick. (2005). Estimates of abundance of the eastern north Pacific stock of gray whales 1997-2002. Journal of Cetacean Research and Management 7 1: 1-12.

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.

Sanzone, D., B. Streever, B. Burgess, and J. Lukin, (Eds.), (2009). Long-term ecological monitoring in BP's North Slope oil fields. 2008 Annual Report for BP Exploration (Alaska), Inc. Anchorage, AK.

Schell, D.M. (1988). Arctic marine ecosystems of the Chukchi and Beaufort Seas. pp. 107-110 In: Proceedings of the 1987 Alaska OCS Region Arctic Information Transfer Meeting Conference. MMS, Alaska OCS Region, Anchorage, AK.

Schell, D.M. and R.A. Horner. (1981). Primary production, zooplankton, and trophic dynamics. Chapter 1 In: D.W. Norton and W.M Sackinger (Eds.), Proceedings of a Synthesis Meeting: Beaufort Sea Sale 71 Synthesis Report. BLM/NOAA/OCSEAP, Juneau, AK.

Schell, D.M., and S.M. Saupe. (1993). Feeding and growth as indicated by stable isotopes. In: Burns, J.J., J.J. Montague, and C.J. Cowles, (Eds.). The Bowhead Whale, *Balaena mysticetus*, Special Publication 2. Lawrence, KS: Society for Marine Mammalogy.

Schell, D.M., P.J. Ziemann, D. Parson, and E.J. Brown. (1982a). Foodweb and nutrient dynamics in nearshore Alaskan Beaufort Sea waters. Cumnl. Simm. Rept. for NOAA, Boulder, CO.

Schell, D.M., P.J. Ziemann, D.M. Parrish, K.H. Dunton, and E.J. Brown. (1982b). Foodweb and nutrient dynamics in nearshore Alaskan Beaufort Sea waters. NOAA/OCSEAP, Anchorage, AK.

Schell, D.M., S.M. Saupe and N. Haubenstock. (1987). Bowhead whale feeding: Allocation of regional habitat importance based on stable isotope abundances. In: Richardson, W. John (Ed.), Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-86. Report by LGL Ecological Research Associates, Inc., to Minerals Management Service.

Schick C.T., G.V. Frost, and R.J. Ritchie. (2004). Spectacled and Steller's eiders surveys and habitat mapping at U. S, Air Force Radar sites in Northern Alaska, 2003. Unpublished report prepared for the U. S. Air Force, Elmendorf Air Force Base, AK, by ABR, Inc.–Environmental Research and Services, Fairbanks, AK. 56 pp.

Schick, C.T., J.H. Boisvert, and S.M. Murphy. (2003). Wildlife surveys at the Pingo-X Prospect, North Slope, Alaska, 2002. Final Report, prepared for Anadarko Petroleum Corporation, Anchorage, AK, by ABR, Inc., Anchorage, AK. 26 pp.

Schlesinger, W.H. (1991). Biogeochemistry: an analysis of global change. Academic Press, San Diego, CA. pp. 443.

Schliebe, S., K.D. Rode, J.S. Gleason, J. Wilder, K. Proffitt, T.J. Evans, and S. Miller. (2008). Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the southern Beaufort Sea. Polar Biology 31: 999-1010.

Schliebe, S., S. Kalxdorff, and T. Evans. (2001). Aerial surveys of polar bears along the coast and barrier islands of the Beaufort Sea, Alaska, September-October 2000. U.S. Fish and Wildlife Service and LGL Research Associates, Inc., Anchorage, AK.

Schliebe, S., T. Evans, K. Johnson, M. Roy, S. Miller, C. Hamilton, R. Meehan, and S. Jahrsdoerfer. (2006). Range-wide status review of the polar bear (*Ursus maritimus*). U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, AK. 262 pp.

Schliebe, S.L., and T.Evans. (2002). Stock assessment for polar bear (*Ursus maritimus*): Alaska Beaufort Sea stock. U.S. Fish and Wildlife Service, Marine Mammals Management, Anchorage, AK.

Schmidt, D.R., W.B. Griffiths and L.R. Martin. (1989). Overwintering biology of anadromous fish in the Sagavanirktok River delta, Alaska. Biological Papers of the University of Alaska 24: 55-74.

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.

Schmutz, J. A. (2009). Model-based predictions of the effects of harvest mortality on population size and trend of yellow-billed loons. U.S. Geological Survey, Open-File Report 2009-1040. 18 pp.

Schneider, W. and D. Libbey. (1979). Historic context of life on the North Slope. In Native Livelihood & Dependence: A Study of Land Use Values Through Time. U.S. Department of the Interior National Petroleum Reserve in Alaska 105(C) Field Study 1. Prepared by North Slope Borough Contract Staff for National Petroleum Reserve in Alaska Work Group 1: Anchorage.

Scott, W.B., and E.J Crossman. (1973). Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Seagars, D.J. (1992). Letter to regional director, U.S. Department of Interior, Minerals Management Service, Alaska OCS Region. Subject: Pacific Walrus Population Estimates. Anchorage, AK: U.S. Department of Interior, U.S. Fish and Wildlife Service.

Sedinger, J.S., and A.A. Stickney. (2000). Black Brant. Chapter 11 in The Natural History of an Arctic Oil Field, J. C. Truett and S. R. Johnson, (Eds.), pp 221-232. New York: Academic Press.

Sellman, PV., J. Brown, R.I. Lewellyn, C.J. Merry, and H.L. McKim. (1975). The classification and geomorphic implications of Thaw Lakes on the Arctic Coastal Plain, Alaska, CRREL Report 344. U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory.

Setterquist, S. (2009). Crowley Maritime Corp. Personal interview. 24 September 2009.

Shaughnessy, P.D. and F.H. Fay. (1977). A Review of the taxonomy and nomenclature of North Pacific harbour seals. Journal of Zoology (London) 182: 385-419.

Sheldon, K.E.W., D.P. DeMaster, D.J. Fugh, and A.M. Olson. (2001). Developing classification criteria under the U.S. Endangered Species Act: Bowhead whales as a case study. Conservation Biology 15 5: 1300-1307.

Shepro, C.E. and D.C. Maas. (1999). 1999 North Slope Borough 1998/99 economic profile and census report: Volume VIII. Prepared for the North Slope Borough Department of Planning and Community Services: Barrow.

Shideler, R., and J. Hechtel. (1993). Oilfield grizzly project—1993 summary. Unpublished report by Alaska Department of Fish and Game, Fairbanks, AK. 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, AK.

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, AK.

Shideler, R., and J. Hechtel. (2000). Grizzly bear. Chapter 6 in The natural history of an arctic oil field: Development and the biota, J. C. Truett and S. R. Johnson, eds., pp. 105-132. San Diego, CA: Academic Press.

Shideler, R.T. (1986). Impacts of human developments and land use on caribou: a literature review. Volume 2, Impacts of oil and gas development on the Central Arctic Herd. Alaska Department of Fish and Game, Division of Habitat. Technical Report No. 86-3. Juneau, AK.

Shideler, R.T. (1998). Grizzly bear use of Pt. Thomson Unit, field season 1998. Alaska Department of Fish and Game, Fairbanks, AK.

Shideler, R.T. (1999). Grizzly bear use of the Point Thomson area cluster, 1999. Alaska Department of Fish and Game, Fairbanks, AK.

Shideler, R.T. (2000). Unpublished data. Alaska Department of Fish and Game, Fairbanks, AK.

Shideler, R.T. (2003). ADF&G, personal communication.

Shideler, R.T. (2009). ADF&G, personal communication.

Simpson, S.G., J. Barzen, L. Hawkins, and T. Pogson. (1982). Waterbird studies on the Colville River delta, Alaska. 1982 Summary Report for the U.S. Fish and Wildlife Service, Special Studies, Anchorage, AK. 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, AK. 27 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. 699 pp.

Sloan, C.E. (1987). Water resources of the North Slope, Alaska. In: Irv Tailleur and Paul Weimer (Eds.), Alaskan North Slope geology: Pacific section. The Pacific Section, Society of Economic Paleontologists and Mineralogists (SEPM) and the Alaska Geological Society, 50: 233-252.

Smardon, R.C., J.F. Palmer, A. Knopf, K. Grinde, J.E Henderson, and L.D. Peyman-Dove. (1988). Visual resources assessment procedure for U.S. Army Corps of Engineers, Instruction Report EL-88-1. Prepared for U.S. Army Corps of Engineers, Washington, DC, by State University of New York, U.S. Army Engineer Waterways Experiment Station (USAEWES), Environmental Laboratory, Syracuse, NY.

Smetzer, M.B. (2008). Polar bear killed near village in interior Alaska. Fairbanks Daily News-Miner.

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, AK. 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, T.G. (1976). Predation of ringed seal pups (*Phoca hispida*) by the Arctic fox (*Alopex lagopus*). 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, T.S., S.T. Partridge, S.C. Amstrup, and S. Schliebe. (2007). Post-den emergence behavior of polar bears (*Ursus maritimus*) in northern Alaska. Arctic 60: 187-194.

Smith, W.T., and R.D. Cameron. (1992). Caribou responses to development infrastructures and mitigation measures implemented in the central Arctic region. In Terrestrial research: 1002 area—Arctic National Wildlife Refuge, interim report 1988-1990, T. R. McCabe, B. Griffith, N. E. Walsh, and D. D. Young, (Eds.), pp. 79-86. Anchorage: U. S. Fish and Wildlife Service.

Sobelman, S.S. (1985). The economics of wild resource use in Shishmaref, Alaska. Technical paper No. 112. Alaska Department of Fish and Game, Division of Subsistence: Juneau.

Sopuck et al. 1986 was incorrectly cited. Please see Carruthers et al. 1987 for correct reference.

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, OH. 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.

Spearman, G., S. Pedersen and W. Brown. (1979). Anaktuvuk Pass synopsis. In: Native Livelihood & Dependence: A Study of Land Use Values Through Time. U.S. Department of the Interior National Petroleum Reserve in Alaska 105(C) Field Study 1. Prepared by North Slope Borough Contract Staff for National Petroleum Reserve in Alaska Work Group 1: Anchorage.

Spindler, M.A. (1979). Bird populations utilizing the coastal tundra, coastal lagoons, and nearshore waters of the Arctic National Wildlife Refuge. Report by U.S. Fish and Wildlife Service, Arctic National Wildlife Range, Fairbanks, Alaska.

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.

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.

Stenhouse, I.J., and S.E. Senner. (2005). Alaska watchlist-2005. Audubon Alaska, Anchorage, AK. Available online at: http://www.audubon.org/chapter/ak/ak/BirdSci_WatchList.html. November 2009.

Stephenson, R.O. (1996). Personal communication. Alaska Department of Fish and Game,~~,~~ Fairbanks, AK.

Stephenson, R.O. (1999). GMU 25A, 25B, 25D, and 26C, Porcupine. In: Caribou, M.V. Hicks, (Ed.), pp. 186-198. Management report, survey-inventory activities, 1 July 1996-30 June 1998. 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, AK.

Stephenson, R.O. (2006). Units 25A, 25B, 25D, 26B, and 26C, wolf. Pages 239-252 in P. Harper, (Ed.), Wolf management report of survey and inventory activities, 1 July 2002-30 June 2005. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau.

Stern, R.O. (1980). I used to have a lot of reindeer: The ethnological and cultural ecology of reindeer herding in northwest Alaska. Ph.D. thesis, Department of Anthropology, State University of New York at Binghamton: Binghamton.

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., B.A. Anderson, R.J. Ritchie, and J.G. King. (2002). Spatial distribution, habitat characteristics, and nest-site selection by tundra Swans on the Central Arctic Coastal Plain, Northern Alaska. Waterbirds 25, Special Publication 1: 227-235.

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). Attraction of polar bears *Ursus Maritimus* to offshore drilling sites in the Eastern Beaufort Sea. Polar Record 24: 1-8.

Stirling, I. (2002). Polar bear *Ursus maritimus*. In: Encyclopedia of Marine Mammals, W. F. Perrin, B. Würsig, J. G. M. Thewissen, (Eds.). San Diego, CA: Academic Press.

Stirling, I., and C.L. Parkinson. (2006). Possible effects of climate warming on selected populations of polar bears (*Ursus maritimus*) in the Canadian Arctic. Arctic 59: 261-275.

Stirling, I., and P. Andriashek. (1992). Terrestrial maternity denning of polar bears in the eastern Beaufort Sea area. Arctic 45: 363-366.

Stirling, I., D. Andriashek, P. Latour, and W. Calvert. (1975). The distribution and abundance of polar bears in the eastern Beaufort Sea. Beaufort Sea Project, Tech. Report 2, Dept. Environ., Victoria, B.C. 59 pp.

Stirling, I., E. Richardson, G.W. Thiemann, and A.E. Derocher. (2008). Unusual predation attempts of polar bears on ringed seals in the southern Beaufort Sea: Possible significance of changing spring ice conditions. Arctic 61: 14-22.

Stirling, I., H. Cleator, and T.G. Smith. (1981). Marine mammals. In: Polynyas in the Canadian Arctic, I. Stirling and H. Cleator, (Eds.), pp. 44-58. Canadian Wildlife Service Occasional Paper 45. Ottawa, Ontario.

Stirling, I., M. Kingsley, and W. Calvert. (1982). The Distribution and Abundance of Seals in the Eastern Beaufort Sea, 1974-79, Occasional Paper No. 47. Edmonton, AB: Environment Canada, Canadian Wildlife Service.

Stirling, I., N.J. Lunn, and J. Iacozza. (1999). Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. Arctic 52: 294-306.

Stratton, L. (1989). Resource harvest and use in Tatitlek, Alaska, Technical Paper No. 181. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Stratton, L. (1992). Cordova: A 1988 update on resource harvests and uses, Technical Paper No. 204. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Stratton, L. 1990. Resource harvest and use in Tatitlek, Alaska. Technical Paper No. 181. Alaska Department of Fish and Game, Division of Subsistence: Juneau.

Stroeve, J., M. Serreze, S. Drobot, S. Gearheard, M. Holland, J. Maslanik, W. Meier, and T. Scambos. (2008). Arctic Sea Ice Extent Plummets in 2007. EOS Transactions, American Geophysical Union 89 2: 13-14.

Stroeve, J., M.M. Holland, W. Meier, T. Scambos, and M. Serreze. (2007). Arctic sea ice decline: Faster than forecast. Geophysical Research Letters 34: L09501.

Suydam, R.S. and J.C. George. (2004). Subsistence harvest of bowhead whales *(Balaena mysticetus*) by Alaskan Eskimos, 1974-2003, Paper SC/56/BRG12. Sorrento, Italy: Paper submitted to the International Whaling Commission Scientific Committee.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. (2007). Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2006, paper SC/59/BRG4. Paper submitted to the International Whaling Commission Scientific Committee.

Suydam, R.S., L.F. Lowry, and K.J. Frost. (2005). Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn, final report, OCS Study, MMS 2005-035. Report by North Slope Borough, Department of Wildlife Management, Barrow, AK, and the University of Alaska Fairbanks, Institute of Marine Science, School of Fisheries and Marine Science, Fairbanks, AK, for Minerals Management Service, Anchorage, AK.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe and D. Pikok, Jr. (2001). Satellite Tracking of Eastern Chukchi Sea Beluga Whales into the Arctic Ocean. Arctic 54 3: 237-243.

Swartz, S.L., B.L. Taylor, and D. Rugh. (2000). Review of studies on stock identity in north Pacific gray whales (*Eschrichtius robustus*), Paper SC/52/SD3. Adelaide, Australia: Paper submitted to International Whaling Commission Scientific Committee.

Symon, C., et al. (Eds.) (2005). Arctic climate impact assessment. Produced by Arctic Climate Impact Assessment. Cambridge, UK, and New York, NY: Cambridge University Press.

Tekmarine, Inc, (1983). Point Thomson coastal processes study. Coastal survey and characterization of processes based on quantitative and historical information.

Thompson, D.W. and J.M. Wallace. (1998). The Arctic oscillation signature in the wintertime geopotential height and temperature fields. Geophysical Research Letters 25 9: 1297-1300.

Thorsteinson, L.K. and W.J. Wilson. (1983). Anadromous fish of the central Alaska Beaufort Sea, National Biological Service and LGL Alaska Research Associates, Inc.

Tiner, R.W., (1989), Wetlands of Rhode Island: Newton Corner, Mass., U.S. Fish and Wildlife Service, National Wetlands Inventory, 71 p., appendix.

Tornfelt, E.E. and M. 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. Available online at: http://www.mms.gov/alaska/ref/ships/index.htm.

Treacy, S.D. (1988). Aerial surveys of endangered whales in the Beaufort Sea, fall 1987, OCS Study, MMS 89-0030. Anchorage, AK: U.S. Department of Interior, Minerals Management Service, Alaska OCS Region.

Treacy, S.D. (1989). Aerial surveys of endangered whales in the Beaufort Sea, fall 1988. OCS Study MMS 89-0033. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1990). Aerial surveys of endangered whales in the Beaufort Sea, fall 1989. OCS Study MMS 90-0047. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1991). Aerial surveys of endangered whales in the Beaufort Sea, fall 1990. OCS Study MMS 91-0055. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1992). Aerial surveys of endangered whales in the Beaufort Sea, fall 1991. OCS Study MMS 92-0017. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1993). Aerial surveys of endangered whales in the Beaufort Sea, fall 1992. OCS Study MMS 93-0023. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1994). Aerial surveys of endangered whales in the Beaufort Sea, fall 1993. OCS Study MMS 94-0032. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1995). Aerial surveys of endangered whales in the Beaufort Sea, fall 1994. OCS Study MMS 95-0033. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1996). Aerial surveys of endangered whales in the Beaufort Sea, fall 1995. OCS Study MMS 96-0006. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1997). Aerial surveys of endangered whales in the Beaufort Sea, fall 1996. OCS Study MMS 97-0016. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (1998). Aerial surveys of endangered whales in the Beaufort Sea, fall 1997. OCS Study MMS 98-0059. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (2000). Aerial surveys of endangered whales in the Beaufort Sea, fall 1998-1999. OCS Study MMS 2000-066. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (2002a). Aerial surveys of endangered whales in the Beaufort Sea, fall 2000. OCS Study MMS 2002-014. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D. (2002b). Aerial surveys of endangered whales in the Beaufort Sea, fall 2001. OCS Study MMS 2002-061. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage.

Treacy, S.D., Jeffrey S. Gleason, and Cleveland J. Cowles. (2006). Offshore distances of bowhead whales (*Balaena mysticetus*) observed during fall in the Beaufort Sea, 1982-2000: An alternative interpretation. Arctic 59 1: 83-90.

Troy Ecological Research Associates (TERA). (1993a). 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. (1993b). Population dynamics of birds in the Pt. McIntyre Reference Area, 1981-1992. Report to BP Exploration (Alaska) Inc., Anchorage, AK. 30 pp.

TERA. (1994). Preliminary characterization of summer bird use of the proposed Badami development area. Unpublished report by Troy Ecological Research Associates for BP Exploration (Alaska) Inc., 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, AK. 20 pp.

TERA. (1999). The Distribution of spectacled eiders in the vicinity of the Point 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 Point Thomson Unit: 1999. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, Anchorage, AK.

TERA. (2002a). Spectacled eiders movement in the Beaufort Sea: distribution and timing of use. Unpublished report. Prepared for BP Exploration (Alaska) Inc., Anchorage, AK, and Bureau of Land Management, Fairbanks AK, by Troy Ecological Research Associates, Anchorage, AK. 22 pp.

TERA. (2002b). The distribution of spectacled eiders in the vicinity of the Point Thomson Unit: 1998-2001. Report for BP Exploration (Alaska) Inc., Anchorage, AK, by Troy Ecological Research Associates, 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, AK.

Troy, D.M. (2000). Shorebirds. Chapter 13 In: The Natural History of an Arctic Oil Field, J. C. Truett and S. R. Johnson, (Eds.), pp. 271-303. New York: Academic Press.

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., (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., 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., and K. Kertell. (1992). Tundra disturbance and ecosystem production: Implications for impact assessment. Environmental Management 16: 485-494.

Truett, J.C., and S.R. Johnson, (Eds.). (2000). The natural history of an arctic oil field: development and the biota. San Diego, CA: Academic Press. 422 pp.

U.S. Army Corps of Engineers (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. (1988). Visual resources assessment procedure for U.S. Army Corps of Engineers, instruction report EL-88-1.

USACE 1999a was incorrectly cited. Please see USACE 1999 for correct reference.

USACE. (1999). Final report environmental impact statement: Beaufort Sea oil and gas development, Northstar project, Vol 3.

U.S. Census Bureau (USCB). (2008). Fact sheet: North Slope Borough, Alaska. Available online at: http://factfinder.com.

U.S. Department of the Interior (USDOI). (1987). The Arctic National Wildlife Refuge, AK., coastal plain resource assessment.

USDOI. (1998). Northeast National Petroleum Reserve-Alaska. Final integrated activity plan/environmental impact statement.

USDOI. (2009). About the Federal Subsistence Program, U.S. Fish and Wildlife Service. http://alaska.fws.gov/asm/about.cfml Accessed November, 2009.

U.S. Fish and Wildlife Service (USFWS). (ND). Available online at: http://www.r7.fws.gov/nwr/arctic/faqs.htm.

USFWS. (1988). Final Arctic National Wildlife Refuge comprehensive conservation plan, environmental impact statement, wilderness review and wild river plans. U.S. Fish and Wildlife Service.

USFWS. (1993a). 12-month finding on a petition to list the spectacled eider as threatened or endangered. Federal Register 58: 27474-27480

USFWS. (1993b). Arctic National Wildlife Refuge river management plan and environmental assessment (draft). U.S. Fish and Wildlife Service. Fairbanks, AK.

USFWS. (1995). Habitat conservation strategy for polar bears in Alaska. Anchorage Alaska.

USFWS. (1996). Spectacled eider recovery plan. U.S Fish and Wildlife Service, Anchorage, AK. 157 pp.

USFWS. (1997). Threatened status for the Alaska breeding population of the Steller's eider. Federal Register 62: 31748-31757.

USFWS. (1999). Population status and trends of sea ducks in Alaska. Unpubl. report by Migratory Bird Management, Waterfowl Management Branch, Anchorage, AK. 81 pp.

USFWS. (2000a). Proposed designation of critical habitat for the spectacled Eider. Federal Register 65: 6114-6131.

USFWS. (2000b). Proposed designation of critical habitat for the Steller's eider. Federal Register 65: 13262-13284.

USFWS. (2001a). Final determination of critical habitat for the spectacled eider. Federal Register 66: 9146-9185.

USFWS. (2001b). Final determination of critical habitat for the Steller's eider. Federal Register 66: 8850-8884.

USFWS. (2002). Steller's eider recovery plan. U.S Fish and Wildlife Service, Fairbanks, AK. 27 pp.

USFWS. (2006a). Alaska's threatened and endangered species. Unpublished report, Anchorage Fish and Wildlife Field Office, Anchorage, AK.

USFWS. (2006b). Conservation agreement for the yellow-billed loon (*Gavia adamsii*). U.S Fish and Wildlife Service, Fairbanks, AK. 29 pp.

USFWS. (2006c). Environmental Assessment: Final rule to authorize the incidental take of small numbers of polar bear (*Ursus maritimus*) and Pacific walrus (*Odobenus rosmarus divergens*) during oil and gas activities in the Beaufort Sea and adjacent coastal Alaska. U.S. Department of the Interior, Fish and Wildlife Service. 97 pp.

USFWS. (2008a). Analysis of listed Steller's eiders. Unpublished report, U.S. Fish and Wildlife Service, Fairbanks, AK.

USFWS. (2008b). Programmatic biological opinion for polar bears (*Ursus maritimus*) on Beaufort Sea incidental take regulations. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, AK. 65 pp.

USFWS. (2009a). Polar bear (*Ursus maritimus*): southern Beaufort Sea stock assessment report (draft). U.S. Fish and Wildlife Service. 9 pp.

USFWS. (2009b). Final biological opinion for Beaufort and Chukchi Sea Program Area lease sales and associated seismic surveys and exploratory drilling. Consultation with Minerals Management Service, Alaska OCS Region, by U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, Fairbanks, AK. 168 pp.

U.S. Geological Survey (USGS). (2005). Avian population response to ecological change along the Arctic coastal plain. Progress report by U.S. Geological Survey, Alaska Science Center, Anchorage, AK. 10 pp.

USGS. (2009). National Earthquake Information Center. Earthquake search results for 200 km radius about Lat. 70.150, Long. -146.140: Earthquake data base, preliminary determination of epicenter(s) and USHIS Catalog. U.S. Geological Survey Web site, accessed 1 September 2009. Available online at: http://neic.usgs.gov/cgi-bin/epic/epic.cgi

U.S. Shorebird Conservation Plan (USSCP). (2009). High priority shorebirds-2004. Unpublished report. U.S. Fish and Wildlife Service, Arlington, VA, 2004. Available online at: http://www.fws.gov/shorebirdplan/.

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.

United Nations Environment Programme (UNEP). (2003). Review of the interlinkages between biological diversity and climate change, and advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto Protocol, UNEP/CBD/SBSTTA/9/11. United Nations Environment Programme, Subsidiary Body on Scientific, Technical, and Technological Advice.

United States Code (USC) (2003). Indian allotment authority in Alaska; revocation; charging allotments on pending application against statutory acreage grant; relocation of allotment. Title 43, United States Code, Part 1617 (43 USC 1617). Available online at: http://vlex.com/vid/charging-pending-statutory-relocation-19255680.

University of Washington, (2001). Background Information on the ShakeMaps. Available online at: http://www.pnsn.org/shake/about.html, last modified 10/9/01, accessed 5/18/09.

Urquhart, D.R. (1973). Oil exploration and Banks Island wildlife: Section D—Arctic fox. Unpublished report by Game Management Division, Government Northwest Territories.

URS Corporation (URS) URS 1998 was cited incorrectly. Please see URS 1999 for correct reference.

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. (2002). Technical memorandum, Point Thomson Unit #3 surface water sampling results. 20 December 2002.

URS. (2003a). Letter report, Point Thomson Gas Cycling Project fresh water recharge assessment.

URS. (2003b). Point Thomson 2003 spring break-up data summary, Point Thomson Gas Cycling Project, North Slope, Alaska. Prepared for: Parsons E&C. Arcadia, CA.

Wahrhaftig, C. (1960). The physiographic provinces of Alaska, open file report 60-146. U.S. Geological Survey: 5-6.

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, Fairbanks, AK. National Academy Press, Washington, D.C.

Walker, D.A. and K.R Everett. (1987). Road dust and its environmental impact on Alaska 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 Monograph. 611991: 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, V. Komarkova, and J. J. Ebersole, (Eds.), Final report to U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

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.

Walters, V. (1955). Fishes of western Arctic America and eastern Arctic. Siberia: Taxonomy and zoogeography. Bulletin of the American Museum of Natural History 106: 259-68.

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: pp. 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. pp. 21.

Warr, D. (2009). Personal interview. U.S. Coast Guard, 24 September 2009.

Wartzok, D., W.A. Watkins, B. Wursig, and C.I. Malme. (1989). Movements and behaviors of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. Report from Purdue University for Amoco Production Company, Anchorage, AK. 228 pp.

Wé, T.L. (1982). Geologic hazards of the Fairbanks area, Alaska, Special Report 15. Alaska Division of Geological and Geophysical Surveys.

Webster, D. and W. Zibell. (1970). Iñupiat Eskimo dictionary. College: Alaska Rural School Project, University of Alaska. xii, pp. 211.

Weingartner, T.J., S.R. Okkonen, and S.L. Danielson, (2005). Circulation and water property variations in the nearshore Alaskan Beaufort Sea, OCS Study MMS. p28-103.

Weller, G.A. and P.A. Anderson (Eds.). (1998). Implications of global change for Alaska and the Bering Sea region, Proceedings of a workshop, June 3-6, 1997. Fairbanks, Alaska: Center for Global Change and Arctic System Research, University of Alaska Fairbanks.

Weller, G.A. (1998). Regional impacts of climate change in the Arctic and Antarctic. Annals of Glaciology 27: 543-552.

Wentworth, C. (1979). Kaktovik synopsis in native livelihood & dependence: A study of land use values through time. National Petroleum Reserve in Alaska Work Group 1 in Cooperation with the North Slope Borough, Field Study 1. Anchorage, AK: U.S. Department of the Interior.

Werbe, E. (1980). Disturbance effects of a gravel highway upon Alaskan tundra vegetation. M.S. thesis, University of Colorado, Boulder. 153 pp.

Wesson, R.L., O.S. Boyd, C.S. Mueller, C.G. Bufe, A.D. Frankel, and M.D. Petersen. (2007). Revision of time-independent probabilistic seismic hazard maps for Alaska, Open File Report 2007-1043. U.S. Geological Survey.

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, (Eds.), Arctic National Wildlife Refuge coastal plain resource assessment: 1984 update report. U.S. Fish and Wildlife Service, Anchorage, AK.

Western Regional Climate Center (WRCC). (2009). 1971 - 2000 Monthly tabular data Prudhoe Bay, Alaska (507780). Available online at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak7780. 17 November 2009, last modified unknown.

Wetzel, R.G. (2001). Liminology: Lake and river ecosystems. San Diego: Academic Press.

Wheeler 2003 was cited incorrectly. Please disregard.

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.

White, D.M., M.R. Lilly, M. Chambers, K.M. Hilton, and P. Prokein. (2006). Lake survey data for the coastal plain from the Sagavanirktok River to Bullen Point: Spring 2006, report INE/WERC 06-02. Fairbanks, AK: University of Alaska Fairbanks, Water and Environmental Research Center.

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. In: Ecological investigations of the tundra biome in the Prudhoe Bay region, J. Broan, (Ed.), pp. 151-201. Fairbanks: Alaska Biological Papers of the Univ.of Alaska, Spec. Report No. 2.

Whitten, K.R. (1995). Porcupine herd. In: Caribou. Management report of survey–inventory activities, 1 July 1992-30 June 1994, M.V. Hicks, (Ed.), pp. 176-186. Federal Aid Wildlife Restoration, Grants W-24-2 and W-24-3, Stud. 3.0, Alaska Dept Fish and Game, Juneau, AK.

Whitten, K.R. (2009). Personal communication.

Whitten, K.R., and R.D. Cameron. (1985). Distribution of calving caribou in relation to the Prudhoe Bay oil field. In: Caribou and human activity, A.M. Martell and D.E. Russell, eds., pp. 35-39. Proceedings of the 1st North American Caribou Workshop. Ottawa, Ontario: Canadian Wildlife Service Publication.

Wiig, O. (1991). Seven bowhead whales (*Balaena mysticetus L.)* Observed at Franz Josef Land in 1990. Marine Mammal Science 7 3: 316-319.

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 report prepared for U.S. Fish and Wildlife Service, Northern Alaska Ecological Services, Fairbanks, AK, by ABR, Inc., Fairbanks, AK. 84 pp. + appendices.

Williams, J.R. and R.O. van Everdingen. (1973). Groundwater investigation in permafrost regions of North America: A review. In: Permafrost, the North American Contribution to the Second International Conference of the National Academy of Sciences, Yakutsk, USSR, 13-28 July 1973. Washington, DC: National Academy of Sciences: 436-466.

Williams, M.T. and J.A. Coltrane (Eds.). (2002). Marine mammal and acoustical monitoring of the Alaska gas producers pipeline team's open water pipeline route survey and shallow hazards program in the Alaskan Beaufort Sea, 2001, LGL report No. P643. Report from LGL Alaska Reseach Associates, Inc., Anchorage, AK, for BP Exploration (Alaska), Inc.; ExxonMobil Production; Phillips Alaska, Inc., and the National Marine Fisheries Service.

Williams, M.T., V.D. Moulton, S.B. Blackwell, W.J. Richardson, and B.J. Streever. (2006). Sensitivity of overwintering ringed seals to construction, drilling, and oil production sounds in the Alaskan Beaufort Sea. Appendix O In: Monitoring of Industrial Sounds, Seals, and Bowhead Whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2004. LGL Report TA4256A. Report from LGL Ltd., King City, Ontario, Greeneridge Sciences Inc., Santa Barbara, CA, and WEST Inc., Cheyenne, WY for BPXA Inc., Anchorage, AK.

Winters, J.F. and W.A. Morris. (2004). Fisheries Investigations in streams crossed by the Proposed Point Thomson Gas Cycling Project, Technical Report No. 04-03. Fairbanks, AK: Alaska Department of Natural Resources, Office of Habitat Management and Permitting.

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, S.C., E. Reimnitz, and P.W. Barnes. (1985). Pleistocene and Holocene seismic stratigraphy between the Canning River and Prudhoe Bay, Beaufort Sea, Alaska, Open File Report 85-549. U.S. Geological Survey.

Wolfe 1996 was cited incorrectly. Please disregard.

Wolfe, R.J. (1983). Understanding resource uses in Alaskan socioeconomic systems. In: Resource Use and Socioeconomic Systems: Case Studies of Fishing and Hunting in Alaskan Communities. Juneau, AK: Alaska Department of Fish and Game, Division of Subsistence.

Wolfe, R.J., J.J. Gross, S.J. Langdon, J.M. Wright, G.K. Sherrod, L.J. Ellanna, V. Sumida, and P.J. Usher. (1984). Subsistence-based economies in coastal communities of southwest Alaska, social and economic studies program, Technical Report No. 95. Prepared for the Alaska Department of Fish and Game, Division of Subsistence, Juneau, AK, and U.S. Department of the Interior, Minerals Management Service, Alaska Region, Anchorage, AK.

Wolfe, S.A. (2000). Habitat selection by calving caribou of the central Arctic herd, 1980-1995. M.S. thesis, University of Alaska, Fairbanks. 83 pp.

Woodby, D.A. and D.B. Botkin. (1993). Stock sizes prior to commercial whaling. In: Burns, J.J., J.J. Montague, and C.J. Cowles, (Eds.). The Bowhead Whale, *Balaena mysticetus*, Special Publication 2. Lawrence, KS: Society for Marine Mammalogy.

Woodward-Clyde Consultants (WCC) (1983). Lisburne development area: 1983 environmental studies. 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.

Woodward-Clyde Consultants and Alaska Biological Research (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. In: Caribou. Management report of survey-inventory activities, 1 July 1992-30 June 1994, M. V. Hicks, (Ed.), pp. 211-224. Federal Aid Wildlife Restoration, Grants W-24-2 and W-24-3, Stud. 3.0. Juneau: Alaska Dept. of Fish and Game.

Worl, R. (1979). Values of subsistence to North Slope Inupiat culture. In: Native Livelihood and Dependence: A Study of Land Use Values Through Time. North Slope Borough Contract Staff. National Petroleum Reserve in Alaska 105(C) Land Use Study Field Study 1. Anchorage, AK: U.S. Department of the Interior, Bureau of Land Management, NPR-A Work Group 1.

WorleyParsons. (2009). Point Thomson Preliminary Construction Plan, USPT-ED-CRPT-01088.

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.

Yokel, D., R. Brumbaugh, D. Huebner, and J. Ver Hoef. (2003). Impacts of seismic trails, camp-move trails and ice roads on tundra vegetation in the Northeast National Petroleum Reserve Alaska (Abstract). Pages 13 In: D. Yokel, (Ed.), Draft Proceedings of Workshop on the Impacts of Winter Exploration Activities on Tundra Soils and Vegetation of Alaska's North Slope. U.S. Bureau of Land Management Fairbanks, AK.

Yokel, F.Y. and Bea, R.G., (1986). Mat foundations for offshore structures in Arctic regions: prepared for U.S. Department of Interior, Minerals Management Service, Reston, Virginia.

Yokel. D., D. Huebner, R. Meyers, D. Nigro, and J. Ver Hoef. (2007). Offsetting versus overlapping ice road routes from year to year: impacts to tundra vegetation. U.S. Department of the Interior, Bureau of Land Management. Alaska Open File Report 112 BLM/AK/ST-07/011+6700+020.

York, G., S.C. Amstrup, and K. Simac. (2004). Using forward-looking infrared (FLIR) imagery to detect polar bear maternal dens: Operations manual. OCS Study MMS 2004-062, prepared for Minerals Management Service, Alaska OCS Region, by U.S. Geological Survey, Alaska Science Center, Anchorage. 58 pp.

Young, D.D., C.L. McIntyre, P.J. Bente, T.R. McCabe, and R.E. Ambrose. (1995). Nesting by golden eagles on the North Slope of the Brooks Range in Northeastern Alaska. Journal of Field Ornithology 66: 373-379.

Young, D.D., T.R. McCabe, R. Ambrose, G.W. Garner, G.J. Weiler, H.V. Reynolds, M. S. Udevitz, D. J. Reed, and B. Griffith. (2002). Predators. In: Arctic Refuge Coastal Plain Terrestrial Wildlife Research Summaries, D. C. Douglas, P. E. Reynolds, and E. B. Rhode, (Eds.), pp. 8-37; pp. 51-53. U.S. Department of the Interior. Biological Science Report USGS/BRD/BSR-2002-0001.

Zeh, J.E. and A.E. Punt. (2004). Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Paper SC/56/BRG1 presented to the International Whaling Commission Scientific Committee, Sorrento, Italy, June 2004. 9p. Submitted to Journal Cetacean Res. Manage.

TABLE 8-1: CONTRIBUTING AUTHORS AND LIST OF PREPARERS

Contributor	Company	Education and Experience	Contribution
James Aldrich	Arctic Hydrologic Consultants	M.S., Environmental Science, University of Alaska, Fairbanks, 1979	Fresh Water Resources and Hydrology
Betty Anderson (deceased)	ABR	M.S., Zoology, University of Alaska, Fairbanks, 1983	Birds; Threatened and Endangered Species (Eiders and Loons)
Christina Anderson	URS	M.S., Environmental Law, Vermont Law School, 2002	Environmental Justice, Deputy Task Leader for Environmental Report
Jeff Barrett	Hart Crowser - Pentec	Ph.D., Ecology, University of Georgia, 1989	Marine and Freshwater Fish
Jay Brueggeman	Canyon Creek Consulting LLC	M.S., Wildlife Ecology, University of Washington, 1977	Marine Mammals
Bob Burgess	ABR	M.S., Wildlife Management, University of Alaska, Fairbanks, 1984	Terrestrial Mammals; Threatened and Endangered Species (Polar Bear)
Bill Craig	URS	B.S., Environmental Studies, Syracuse University, 1990	Deputy Project Manager
Peter Crews	URS	B.S., Civil Engineering, University of Alaska, Anchorage, 2000	Transportation
Jan Deick	Golder Associates	M.S., Hydrology, University of Idaho, 1986	Geology and Geomorphology
Andy Dimitriou	SLR International	M.S., Geology, University of Massachusetts, Amherst, 1990	Product Spill Risk Analysis
Bob Dugan	Golder Associates	B.A., Geology, University of Colorado, 1970	Geology and Geomorphology
Bob Elder	MWH	Ph.D., Limnology, University of Wyoming, 1980	Fresh Water Resources and Hydrology
Michael Galginaitis	Applied Sociocultural Research	B.A., Social and Behavioral Sciences, The Johns Hopkins University, 1973	Socioeconomic and Subsistence and Traditional Land Use
Brian Geise	URS	B.S., Civil Engineering, University of Alaska, Anchorage, 2008	Transportation
Sandra Hamann	MWH	M.S., Plant Physiology, University of Maryland, 1979	Fresh Water Resources and Hydrology
Brian Hoeffler	Hoefler Consulting Group	M.S.C.E., Civil Engineering, University of Washington, 1991	Meteorology and Air Quality
Jon Houghton	Hart Crowser - Pentec	Ph.D., Intertidal Ecology, University of Washington, 1973	Marine and Freshwater Fish

Contributor	Company	Education and Experience	Contribution
Amanda Huck	SLR International	B.A., Journalism and Public Communications, University of Alaska, Anchorage, 2003	Product Spill Risk Analysis
Jon Isaacs	URS	B.A., Environmental Studies, University of California, Santa Barbara. 1972	Task Leader for Environmental Report, and Land Use
Susan Ives	Oasis Environmental	M.S., Environmental Science, Alaska Pacific University (candidate); B.A. Biology, Oberlin College, 2000	Marine Benthos and Vegetation and Wetlands
Doug Jones	Coastline Engineering	Ph.D., Coastal Engineering, University of Florida, 1975	Physical Oceanography and Coastal Water Resources
Louise Kling	URS	M.S., Fisheries and Wildlife Ecology, Utah State University, (Pending Thesis Defense)	Visual Aesthetics
Joan Kluwe	URS	Ph.D., Natural Resources, University of Idaho, 2002	Recreation
Monica Koethke	SLR International	B.S., Engineering: Civil Sequence, Idaho State University, 1986	Product Spill Risk Analysis
Brian Lawhead	ABR	M.S., Wildlife Management, University of Alaska, Fairbanks, 1983	Terrestrial Mammals; Threatened and Endangered Species (Polar Bear)
Ted Lindberg	URS	B.S., Mathematics, California State University, Long Beach, 1983	Noise
Chris Lindsey	Hoefler Consulting Group	B.S., Biology, University of Texas, Austin, 1996	Meteorology and Air Quality
Simon Mawson	SLR International	M.S., Environmental Engineering, Washington State University 1980	Product Spill Risk Analysis
Adam McCullough	Oasis Environmental	B.S., GIS and Remote Sensing, Humboldt State University, 2005	Graphics
Lydia Miner	SLR International	B.A., Geology-Environmental Studies, Whitman College, 1983	Product Spill Risk Analysis
Deborah Moore	SLR International	M.S., Environmental Law, Master of Studies in Environmental Law, Vermont Law School, 2000	Product Spill Risk Analysis
Kimberly Nielsen	URS	B.S., Ocean Engineering, Florida Institute of Technology, 1993	Physical Oceanography and Coastal Water Resources
Haley Ohms	Oasis Environmental	B.S., Natural Sciences, University of Alaska, Anchorage, 2006	Marine Benthos and Vegetation and Wetlands
Ron Reeves	URS	B.S., Information Systems, Western Carolina University, 1982	Noise
Stephen Rideout	URS	B.S., Wildlife Biology (Minor in GIS), University of Guelph, Ontario, Canada, 2000	Graphics
Lael Rogan	SLR International	M.S., Forestry, Emphasis on GIS and Remote Sensing, Oregon State University, Corvallis, 2000	Product Spill Risk Analysis

Contributor	Company	Education and Experience	Contribution
Terry Schick	ABR	Ph.D., Evolutionary Biology, University of California, Santa Barbara, 1999	Birds
Chandler Short	Oasis Environmental	B.S., Geology, University of Texas, Arlington, (in progress)	Graphics
Michael Sotak	ASRC Energy Services	M.S., Biology, West Virginia University, 1968	Project Description and Alternatives
Mark Stelljes	SLR International	Ph.D., Environmental Toxicology/Pharmacology, University of California, Davis 1990	Product Spill Risk Analysis
Jason Stutes	Hart Crowser - Pentec	Ph.D., Marine Sciences, University of South Alabama, 2007	Marine and Freshwater Fish
Katriina Timm	SLR International	M.S., Environmental Science, Alaska Pacific University, Anchorage, 2006	Product Spill Risk Analysis
Al Trbovich	Hoefler Consulting Group	M.S., Meteorology, University of Utah, 1981	Meteorology and Air Quality
Dave Trudgen	Oasis Environmental	B.S., Wildlife Biology and Management, Michigan State University, 1976	Marine Benthos and Vegetation and Wetlands and Mitigation Measures
Krista Webb	Oasis Environmental	M.S., Biology, Northeastern University, 1992	Marine Benthos, Vegetation and Wetlands, and Mitigation
Don West	Golder Associates	M.S., Geological Sciences, California State University, Hayward, 1981	Geology and Geomorphology
Chris Wooley	Chumis Cultural Resource Services	M.A., Anthropology, Washington State University, 1983	Cultural Resources, Socioeconomic and Subsistence and Traditional Land Use
Wayne Wooster	ASRC Energy Services	M.S., Environmental Engineering, Oregon State University, 1990	Climate

TABLE 8-2: INDEPENDENT TECHNICAL REVIEWERS

Contributor	Company	Education and Experience	Independent Review of the Following Section(s):
James Dietzmann	URS	B.S., Watershed Science (Minor, Soil Resources and Conservation) Colorado State University,1994	Fresh Water Resources and Hydrology
Dave Erikson	URS	M.S., Biology, University of Nevada, Reno 1972. 35 years of experience.	Fish, Birds, Terrestrial Mammals, and Threatened and Endangered Species
Michael Gray	URS	B.A., Geology, Humboldt State University, 1986	Geology and Geomorphology
John Hechtel	Bearsense	M.S., Wildlife Biology, University of Montana, Missoula, 1985	Polar Bears
Jon Isaacs	URS	B.A., Environmental Studies, University of California, Santa Barbara, 1972	Socioeconomics, Subsistence and Traditional Land Use, Transportation, Recreation, Environmental Justice
Mark Jennings	URS	B.A., Geography, University of South Florida, 1982. 23 years experience in transportation planning, preliminary engineering and environmental studies, project management and NEPA documentation	Transportation
Mike Kelly	URS	M.A., Anthropology, University of Nevada, Las Vegas, 1986	Cultural Resources
Richard Kleinleder	URS	M.S., Biology, University of Alaska, Fairbanks, 1985	Marine Benthos and Vegetation and Wetlands
John Lague	URS	M.S., Meteorology, Massachusetts Institute of Technology, 1973	Meteorology and Air Quality and Climate
Amy Lewis	URS	M.S., Environmental Science, Alaska Pacific University, 2003	Visual Aesthetics
Alan Niedoroda	URS	Ph.D., Geology, Florida State University, 1972	Physical Oceanography and Coastal Water Resources
Anne Southam	URS	M.S., Environmental Science, University of North Texas, 2000	Cumulative Effects and Marine Mammals
Craig Wilson	MWH	B.S., Environmental Managements & Emergency Management, Rochester Institute of Technology, 2002; B.A., Physics, State University of New York, Plattsburgh, 1986	Product Spill Risk Analysis
Sheyna Wisdom	URS	M.S., Marine Science, University of San Diego, 2000. 11 years experience in acoustical and biological assessments	Noise