BEAUFORT SEA OIL AND GAS DEVELOPMENT/ NORTHSTAR PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

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LIST OF ACRONYMS AND ABBREVIATIONS

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AAC	Alaska Administrative Code
ACMP	Alaska Coastal Management Program
ACS	Alaska Clean Seas
A.D.	Anno Domini
ADEC	Alaska Department of Environmental Conservation
ADL	Alaska Division of Lands
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
ANCSA	Alaska Native Claims Settlement Act
ANWR	Arctic National Wildlife Refuge
ARCO	Atlantic Richfield Company (or ARCO Alaska, Inc., a subsidiary)
ARRC	Alaska Railroad Corporation
AS	Alaska Statute
BACT	Best Available Control Technology
barrels/day	barrels per day
BLM	Bureau of Land Management (USDOI)
B.P.	Before Present
BPXA	BP Exploration (Alaska) Inc.
Btu/hr	British thermal units per hour
°C	degrees Celsius
CAA	Clean Air Act
CAH	Central Arctic Herd (Caribou)
CCP	Central Compressor Plant
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIDS	Concrete Island Drilling Structure
cm	centimeter(s)
CMP	Coastal Management Plan
CO	carbon monoxide
COFR	Certificate of Financial Responsibility
Corps	U.S. Army Engineer District, Alaska
CRI	Caisson Retained Island
dB	decibel(s)
dBA	A-weighted sound level
DEIS	Draft Environmental Impact Statement
DEW	Distant Early Warning (Line)
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
°F	degrees Fahrenheit

FEIS	Final Environmental Impact Statement
FR	Federal Register
ft	foot, feet
ft^3	cubic feet
ft/yr	feet per year
GCM	Global Climate Model
gpd	gallons per day
Hz	Hertz
INTEC	INTEC Engineering, Inc.
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer(s)
km/hour	kilometers per hour
km^2	square kilometer(s)
liters/day	liters per day
LMRs	land management regulations
m	meter(s)
m^3	cubic meter(s)
m/yr	meters per year
m^3/s	cubic meter(s) per second
mg/L	milligrams per liter
MLLW	mean lower low water
mm	millimeter(s)
MMS	Minerals Management Service (USDOI)
mph	miles per hour
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service (USDOC)
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration (USDOC)
NPDES	National Pollutant Discharge Elimination System
NPRA	National Petroleum Reserve - Alaska (formerly Naval Petroleum Reserve Number 4)
NSB	North Slope Borough
NTU	nephelometric turbidity units
NWI	National Wetlands Inventory
OCS	Outer Continental Shelf
ODCE	Ocean Discharge Criteria Evaluation
ODPCP	Oil Discharge prevention and Contingency Plan
%	percent
pH	potential of Hydrogen (measures the acidity or alkalinity of a substance)
PM1	Point McIntyre No. 1
PM_{10}	particulate matter less than 10 microns in diameter

PM2	Point McIntyre No. 2
PPA	Pressure Point Analysis
ppm	parts per million
ppt	parts per thousand
Put 23	Put 23 Oxbow
PSD	Prevention of Significant Deterioration
ROD	Record of Decision
s	second
SCADA	Supervisory Control and Data Acquisition
sec	second
SHPO	State Historic Preservation Officer (or Office)
SO_2	sulfur dioxide
SPCC	Spill Prevention Containment, and Countermeasure (Plan)
SPL	sound pressure level
SPO	State Pipeline Office
SSDC	Single Steel Drilling Caisson
STP	seawater treatment plant
TAPS	Trans Alaska Pipeline System
TOC	total organic carbon
tpy	tons per year
µg-at/L	microgram atoms per liter
UIC	Underground Injection Control (Permit)
µPa	microPascal
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service (USDOI)
VOCs	volatile organic compounds
VSMs	vertical support members
yd^3	cubic yard(s)

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CHAPTER 5.0

AFFECTED PHYSICAL ENVIRONMENT AND IMPACTS

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5.0 AFFECTED PHYSICAL ENVIRONMENT AND IMPACTS

5.1 INTRODUCTION

Chapter 5 presents the environmental setting and potential impacts of each alternative on the physical environment. Aspects of the physical environment addressed in this chapter include geology, hydrology, water quality, meteorology, air quality, oceanography, and sea ice. Information in this chapter also supports National Environmental Policy Act (NEPA) decision-making for water discharge National Pollutant Discharge Elimination System (NPDES) and ocean dumping (Section 103) permits.

The information presented in Chapter 5 describes the physical environment in the vicinity of the Northstar Unit and demonstrates how aspects of the physical environment drive selection of alternatives as presented in Chapter 4. Impacts of these alternatives on physical environmental resources are also discussed. The criteria used to determine if an impact on the physical environment is potentially significant were determined based on the NEPA definition of significance, which requires consideration of context (as it affects the affected region, the affected discipline, and the locality) and intensity or severity of the impact. The range of severity/intensity includes none (no impact), negligible, minor, and significant as defined in Section 1.8. The analysis of intensity considered the magnitude of the impact, the geographic extent, duration and frequency, and the likelihood of an impact occurring. Professional expertise and judgement, based on available engineering and scientific data, were used to determine if an impact was significant and, therefore, would require avoidance or minimization to reduce the impact. The text highlights design or operational features of each alternative that are principally responsible for identified impacts, or which substantially reduce impacts that might otherwise occur.

Chapter 5 addresses the following issues related to the project's potential impacts on the physical environment. Issues related to impacts of the physical environment on the project are also addressed.

Issues/Concerns	Section
· Would gravel mining operations at the Kuparuk River affect the channel morphology of the river?	5.3.2
· Would freshwater withdrawals for ice road construction affect lake levels or water quality?	5.3.2
· How would island reconstruction affect sediment quality?	5.3.2
· Would onshore pipeline construction disturb soils, lakes, or rivers?	5.3.2
· Would offshore pipeline construction affect sediment quality?	5.3.2
· Would the stratigraphy underlying Seal Island be conducive to the use of waste injection wells?	5.3.2
· Would subsurface gas affect drilling operations?	5.3.2
· Would island discharges affect sediment quality?	5.3.2
· Would permafrost thaw settlement affect the integrity of the island, offshore pipeline, or shore approach?	5.3.2
· What effect would oil removal have on geologic formations?	5.3.2

Issues/Concerns	Section
· Could pipeline vibration affect pipeline stability?	5.3.2
· What effect would the pipeline have on onshore permafrost?	5.3.2
· Would physical hydrologic processes have a detrimental effect on the onshore pipeline?	5.3.2
· Would coastal erosion affect pipeline integrity?	5.3.2
· Would shoreline disturbances alter coastal erosion patterns?	5.3.2
· Would extension of barrier islands by natural processes affect offshore pipeline integrity?	5.3.2
· Would marine sediment erosion affect the pipeline?	5.3.2
· How would an oil spill affect soils, onshore water bodies, or seafloor sediment?	5.3.2
· Would pipeline inspections/repairs affect soils onshore or sediment quality offshore?	5.3.2
· What would be the sources of air emissions during construction, drilling, and operation activities, and what would be the project impacts upon project area air quality?	5.4.2
· What would be the effects of island reconstruction activities on the bathymetry and marine water quality in the vicinity of the island?	5.5.2
· What would be the effects of pipeline construction on marine water quality and bathymetry?	5.5.2
· Would currents in the project area be altered by the reconstructed Seal Island?	5.5.2
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· How would the submarine portion of the pipeline be protected against damage from ice gouging?	5.6.2
· Could strudel scour expose the buried submarine pipeline?	5.6.2
· Could damage to the pipeline by an ice gouge or by strudel scour be detected?	5.6.2
· How would an oil spill affect sea ice in the project area?	5.6.2
· How would the pipeline be accessed for repairs?	5.6.2

5.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge is included in this Environmental Impact Statement (EIS) in acknowledgment of the vast, valuable body of information about the Arctic that the Inupiat people have accumulated over many generations. This knowledge contributes, along with western science, to a more complete understanding of the Arctic ecosystem. Although Traditional Knowledge has been accumulating for a much longer time than western science, it has been maintained orally and been recorded sporadically. While such transcriptions have occurred coincident to various research efforts, they rarely have been focused directly on the topics of this EIS. Therefore, in this effort to collect references to Traditional Knowledge on specific topics such as weather, marine conditions, and sea ice, the results are fragmentary and in no way represent the complete body of Traditional Knowledge on these topics.

Traditional Knowledge on the physical environment was obtained from testimony by village elders, whaling captains, and other individuals from the villages of Barrow, Nuiqsut, and Kaktovik at the majority of hearings on North Slope oil and gas development held since 1979. Information also was obtained through personal interviews with interested individuals near the project area. Reviews of engineering studies and environmental reports associated with previous and ongoing oil and gas exploration and development activities provided a source of additional Traditional Knowledge. Published and unpublished scientific reports and data; and environmental reports and studies conducted by universities, the oil industry, federal and state agencies, and the North Slope Borough also were used as sources for Traditional Knowledge.

Inupiat names are spelled according to the transcripts of the hearings, and some statements have been paraphrased to make the information readily understandable.

5.2.1 Geology and Hydrology

Relatively little Traditional Knowledge has been recorded on geology and hydrology issues. Pertinent information that is available focuses on Inupiat experience with erosion and rivers.

5.2.1.1 Geology

In community meetings held in Barrow, a whaling captain made the point that over the years, all the barrier islands from Point Barrow to Dease Inlet along Elson Lagoon, located about 130 miles (209 kilometers [km]) west of the project area, have reduced in size because of the ice (Pers. Comm., Barrow Whaling Captains Meeting, August 27 and 28, 1996:1). Kenneth Toovak, also of Barrow, reported in past testimony for the Diapir Field EIS that, *"Erosion from wind, waves, and storms can be very severe...and should be considered in all decision-making steps."* (USDOI, MMS, 1983:71).

5.2.1.2 Hydrology

Observations of water levels in rivers rising during storms have been made by both Barrow and Nuiqsut residents. A whaling captain in Barrow reported that the biggest storms occur in September, causing water levels in the rivers to rise. Archie Ahkiviana, a Nuiqsut whaling captain, reported that rising marine water levels during a storm surge can force water over the top of sea ice and flood the river drainage in their area to a distance of 18 miles (29 km) (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8).

5.2.2 Meteorology and Air Quality

Traditional Knowledge on weather and air quality encompasses wind direction, short-term and long-term changes in climate, storms and precipitation, and arctic haze. In discussions on weather, Inupiat residents usually stress the interaction among various physical phenomena; for example, the cause and effect relationship among winds, currents, and ice movement.

5.2.2.1 Weather

Inupiat residents have relayed knowledge on weather in various accounts. Nuiqsut whaling captains explained that Seal Island is most vulnerable to a southwest wind, compared to the milder effects of a northeast wind (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). A Barrow whaling captain reported that in fall and winter the prevailing wind is northeast, with occasional strong west winds. Nuiqsut elder Sarah Kunaknana grew up in the project area and reported that storms can come from different directions, but usually are from the north, and observed that the area inside the barrier islands is not affected heavily by storms (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

Warren Matumeak, a Barrow resident, reported that during the last part of September or October the weather begins to change; typically snow is falling, and fog and ice form during this period (USDOI, MMS, 1990:41). Nuiqsut hunters pointed out that snow drifting around Seal Island will begin in October, explaining that October through December are the critical months for snow drifts. A Nuiqsut resident indicated that in recent years there have been climate changes resulting in warmer temperatures. Residents recently observed blue jays for the first time in these northern areas (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:4).

Inupiat residents have relayed numerous accounts of their experience with extreme wind and storm events. Thomas Napageak, a Nuiqsut whaling captain, described an incident where a boat was swamped after abandoning a whale because, *"The wind got so fierce, south, southwest wind..[at] night."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). Sarah Kunaknana indicated that a warm breeze and warming temperatures in the summer are indicators of an impending major storm (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). In recent public meetings, Barrow whaling captains John Nusunginya and James Ahsoak described how the weather changes constantly and is very unpredictable, and that the biggest storms occur in September (Pers. Comm., Barrow Whaling Captains Meetings, August 27 and 28, 1996:3). Jonas Ningeok, a Kaktovik resident, described the sudden and extreme storms that occur in the Alaskan Beaufort Sea: *"...from experience, I know no matter how beautiful the day may look, in a moment's time, we can have a snow storm...that you can't even see [the] distance...to the end of the table.... It doesn't happen every year, but when it does happen, there's no* *telling [when].... As we were growing up, there have been several times when my...father [would] look up at the clouds, the sky, and tell us to get everything...all the firewood.... We'd get everything ready, and without any notice at all, it would seem like that all this storm would come upon us..."* (USDOI, MMS, 1990:20-21).

Thomas Napageak explained how whaling camps are located partly based on wind protection considerations: "*[camps] ...used to be at Narwhal [Island], but we abandoned that due to the fact that...you got no protection from fierce winds or winds from any direction. You are out in the open. But at Cross [Island], you are in a cove where you have shelter from both the south and northeast wind and north wind. Even if its offshore wind, you can get into one of the smaller coves and have protection...we find the protection that we want at Cross Island, regardless of the weather conditions."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:27).

5.2.2.2 Air Pollution

Very little Traditional Knowledge on air quality issues was found in a review of testimony by local residents. At a public hearing on Lease Sale 144, Frank Long, Jr., a Nuiqsut whaling captain, observed: *"...there is air pollution by the [oil] industry that forms and shifts every which way the wind turns. It's a yellow smog that you can see this time of year [November] till spring."* (USDOI, MMS, 1995:23). Joseph Akpik, another Nuiqsut resident, stated: *"There's a hydrocarbon fallout that is going on.... I've seen it; it's just like smog out there. The cold weather sets in from the air, and it keeps that hydrocarbon fumes coming out, and it falls out to the tundra and the waterways..."* (USDOI, MMS, 1995:31-32).

5.2.3 Physical Oceanography and Marine Water Quality

From the point of view of local residents, several factors determine the behavior of the physical marine environment, including the season of the year. Local residents understand that different aspects of the marine environment are tied together and work in combination to create dangerous conditions. Much of Inupiat knowledge regarding the offshore environment has been derived from their experiences during the fall whaling season, which can extend from the last week in August through early November (T. Napageak and F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:16). Late summer and fall is considered a dangerous time in the project area offshore of Nuiqsut and near Cross Island, with the occurrence of storms, storm surge flooding, and the formation and movement of ice. Unpredictable conditions during this period, particularly with respect to moving young ice, result in elders warning hunters not to go out because of the risk involved (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:1).

5.2.3.1 Water Levels

In a Northstar public meeting, Thomas Napageak relayed knowledge of the interaction between wind and water levels: *"...you don't get...high tides [storm surges] on a northeast wind.... But when we've got the southwesterly wind, that's when the tide [water level] comes up."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:7). Nuiqsut residents spoke of big storm surges occurring at Cross Island, accompanied by two-story high waves, high winds, and flooding across the center of the island. They gave an account of a storm that occurred during the second week of September one year, when sand bags were used to control water at Cross Island, and they had to pull out and run to higher ground (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

Frank Long, Jr. described how a rising tide or storm surge can force water over the top of sea ice and flood river drainages, *"If there's enough water that comes in, it'll bring the ice up, plus water will be flowing...up over the edge."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8). An example of a negative storm surge was also observed by Nuiqsut whaling captains who reported that, in 1977, the water drained out of a bay near Oliktok Point and then came back in (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3).

5.2.3.2 Currents

Nuiqsut residents indicated that currents are very strong in early fall and move from west to east (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). They also indicated that currents resulting from a northeast wind are not as strong or dangerous as currents resulting from a southwest wind. Thomas Napageak reported: *"From...northeast, wind and current is not [as]...fierce.... South southwest wind, that's the wind that...Seal Island is going to be in danger [of]...the current is very strong, and...they both work together, the current and the wind."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:6-7).

Inupiat residents have relayed observations of the currents changing with distance from shore and location along the coast. Frank Long, Jr. indicated, *"The further you go [out from shore], the stronger it gets."* (USDOI, MMS, 1995:24). Nuiqsut whaling captains spoke of a strong current they have encountered during the fall whaling season offshore of Cross Island, sometimes at a distance of about 40 miles (64 km). Thomas Napageak reported: *"...from Cross Island, it moves in and out. You can get to it...sometimes in half an hour, sometimes hour and a half, by outboard.... This movement...ties in with Point Barrow current."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). According to Frank Long, Jr., the location of this current, *"...move[s] every year...just like everything else, it sways."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). *"We had to go 40 miles or so out there to get to those whales who were migrating.... And that's when we run into super heavy fast current that don't need no wind force to help it. It helps itself, break its waves."* (T. Napageak and F. Long, Jr., Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:16). Nuiqsut residents spoke of Seal Island lying just far enough toward the shore to avoid the zone of major current movement, and that Northstar Island is in a much more dangerous place (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). During testimony given at public hearings for the Diapir Field lease sale (Chukchi Sea), Barrow resident Arnold Brower, Jr. stated, *"...the area from Midway Island [near Barrow] to Flaxman Island...has even stronger currents in comparison to the proposed area of the lease sale."* (USDOI, 1982:43).

A Barrow whaling captain explained that when the wind hits the top of the ocean and forces the current down and causes it to change, it swirls and creates underwater storms. Combined with the presence of broken ice, these swirling conditions can be extremely dangerous (Pers. Comm., Barrow Whaling Captains Meetings, August 27 and 28, 1996:1). A Nuiqsut whaling captain remarked that there is free water always moving underneath the ice, especially with a southwest wind (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). Ben Nunqasuk expressed concern about the strength of the currents through an interpreter: *"He doesn't want drilling because he knows the sea is rough and the current is strong, it can do anything without even the help of the wind. The current is so strong that it can damage anything."* (USDOI, MMS, 1982:46). In addition, under solid ice cover, Inupiat residents also have relayed observations of under-ice currents and currents changing with depth. Nuiqsut residents spoke of constantly changing currents, different in magnitude on the surface and bottom (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:4).

5.2.4 Sea Ice

Through Traditional Knowledge, Inupiat residents often describe the power of sea ice and its movements along the Alaskan Beaufort Sea coast. As with physical oceanography, the interaction between storms, currents, wind, and ice affects the behavior of ice. Similarly, the interaction of polar pack ice and "young" ice that forms annually affects ice movement and behavior.

5.2.4.1 Ice Formation and Zonation

Inupiat knowledge of sea ice zones distinguishes between a floating landfast zone, a shear zone, and the Arctic (or polar) ice pack. Thomas Napageak indicated local knowledge of ice zones near Cross and Seal Islands: *"...the floating ice is usually located about three-quarters of a mile from the sand spit [at Cross Island],...where it's deep, it hits bottom there, that's how far [towards shore] the Arctic ice pack gets to be. But over at Seal Island, it's much further out.... But anything in between is something that has, is formed yearly. And it crushes by this Arctic ice pack."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:6). Nuiqsut whaling captains indicated that Seal Island is in a more stable nearshore zone with respect to ice and current conditions than Northstar Island, where currents and movement of the polar pack are much stronger. They report that the polar ice pack does not reach Seal Island because it is too heavy and becomes grounded before it gets there (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2).

Rex Okakok of Barrow stated: *"Sea ice, and icebergs, constitute potentially the most serious natural hazards in the Arctic ... The effect of the sea ice is both variable and patchy in its role as discontinuous boundary with consequences for the surface fluxes of momentum, mass, and energy, and for the resultant circulation and mixing."* (USDOI, MMS, 1987:34).

Frank Long, Jr. relayed his observations of the polar ice pack: *"... ice...not only form[s] on shore; it's* *already out there. It's out there year round, 365 days a year."* (USDOI, MMS, 1995:24). Thomas Napageak stated: *"The polar ice pack is visible most of the years. I would say that within all the time I've been whaling out there [23 years], there were three seasons that the polar ice pack was too far out for me to even see."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:11).

One Nuiqsut resident mentioned that there have been changes in ice formation patterns in recent years, indicating that the ice is not forming the way it used to and that animals (probably seals) are going farther out and following the ice to find food (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:4).

5.2.4.2 Ice Season

Inupiat residents provided comments on the occurrence of sea ice during different seasons of the year. Joseph Nukapigak stated, *"...In the Arctic, nine months out of the year...we have sea ice."* (USDOI, MMS, 1995:15-16). Thomas Napageak remarked: *"...The critical months [for ice formation] are October, November, and December. After the first of the year, the ice is solid enough that you'll start moving further north from the shore-fast ice."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:7). Elijah Kakinya, an Anaktuvik elder, stated: *"In summer months, when there is a westerly wind, you can see [polar pack] ice from shore. But when the wind is blowing from northeasterly, the ice always goes out...you can't see any ice from shore when the wind is blowing from the northeast..."* (NSB, 1980:152).

5.2.4.3 Ice Movement

Inupiat residents consider October through December to be the most critical months of the year for ice movement hazards offshore of Nuiqsut and near Cross Island, due to storm conditions and the formation and movement of ice (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:1-3). Nuiqsut whaling captains explained that Seal Island is most vulnerable to ice movement in a southwest wind, compared to the milder effects of a northeast wind. Extremely hazardous conditions result from a combination of storm, current, tide and ice factors, particularly with a southwest wind. Momentum generated by moving polar ice under these conditions pushes and accelerates young ice that is 1 to 2 feet (ft) (0.3 to 0.6 meters [m]) thick (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:1). Samuel Kunaknana, a Nuiqsut elder, stated: *"It's always a real hazard, especially when the wind is from the west during the wintertime. But at this time of year [April]...when the ice is more solid,...it would seem it was less hazardous than during early winter."* (USDOI, MMS, 1990:29). Michael Jeffrey of Barrow explained that when wind combines with strong currents, these elements can move the entire ice sheet *"...and there's nothing that's going to stop it."* (USDOI, MMS, 1982:32-33).

Inupiat residents note that changes in wind direction are responsible for shifting the ice pack, and that anytime the wind shifts, the ice pack follows. Frank Long, Jr. stated, *"...Every time the wind shifts, the [polar] ice pack will start to shift around, when the wind changes back, then it goes back again."* (Pers.

Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:10). Otis Ahkivgak reported: *"The wind controls the ice movements. When there is no wind, there is no ice movement, but whenever the winds are strong, the ice starts moving. It always happens like that as far as I know."* (NSB, 1980:100).

Inupiat residents observe that the polar ice pack provides the force that moves young ice. This young, forming ice is of primary concern to whalers with respect to ice movement hazards. Thomas Napageak stated: *"...about 50 years I have been in the Arctic area...using the subsistence resources of the sea. I've never seen the polar ice pack tearing up.... The most dangerous of the...ice conditions...[concerns] the ice that is formed...from the mainland out to the Arctic ice pack; the polar ice pack is the force that tears up this ice..."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). He also observed on ice movement: *"...for the wind to push the arctic ice pack towards shore; ...there's no current--it's the wind that's doing it. It'll stop when it gets into shallow water. There's hardly any force on it."* (Pers. Comm., Nuiqsut Whaling Captains Meetings, August 13, 1996:12).

Nuiqsut whaling captains speak of the power of the ice and ocean when combined with currents, wind, and storm conditions. They indicate it is often unpredictable and moves fast. Polar pack ice can gain speeds of 3 to 6 knots (6 to 11 km/hour) when it moves, which pushes the young ice and smaller floes, causing it to "swing around" at speeds of up to 8 to 12 knots (15 to 22 km/hour) (A. Ahkiviana - Pers. Comm., Nuiqsut Whaling Captains Meetings, August 13, 1996:3; F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:9).

Residents have relayed many incidents of people killed on the ice during movement events (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:1). The swiftness of the event is illustrated by Thomas Napageak's example: *"Back in the...1940s,...a family of four traveling in...December...[in] this ice that has formed itself this side of the arctic/polar ice pack. The wind hit as they were traveling by dog team.... It was stormy, blowing, and it was south wind, like the wind...when the tide [storm surge] comes up. That polar ice pack moves swiftly. That's when right in their path, it cracked opened up and closed again. ...The ice being pushed by this polar ice pack...went up.... The two kids...got under and [it] flatten out again. In the meantime, part of it cracked open. The wife fell down and [it] closed on her, caught her. Her husband grab his knife and tried to chop the ice out, but she went down anyway."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:4). Nolan Solomon, a Kaktovik whaler, described being stranded on the ice when it began to move and all the boats were crushed (USDOI, 1990:29-30).

Wildlife is affected by ice movement also. Samuel Kunaknana stated: *"The animals, like people, travel to stay alive. The people in turn follow the animals, because this is what they live on. The polar bears live on the ice, but a female does not have her young on the ice, knowing how the ice moves. ...They know that the ice never stops moving and [is] threatening to live on."* (USDOI, MMS, 1979:5).

Landfast Ice Movement: Inupiat residents have relayed incidents of apparently stable landfast ice breaking off from the mainland and floating away. Thomas Napageak indicated that this phenomenon could happen anywhere and gave an account of an incident in the late 1980s, when, during the month of November, barges tied together were ripped from their concrete moorings at West Dock and taken to Barter Island (to the east) by the movement of the ice (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:5). *"A lot of good stories about the ice breaking up on people, and while trying to get help by foot, [they] froze to death. ...In Barrow...area, there have been people that have been floated out, but they've always come back."* (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:6). He reported: *"[In the] Pole Island area,...a family was moving from...either Brownville or Flaxman on their way to Tiragroak to meet with families there for Christmas week holidays. That's when it happened....the ice went out, broke off the edge and just float the people out...they were out there drifting around for about a week. Evidently, when it freezes over again or the lead closes, they managed to get back to their homes."* (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:4).

The effects of the vertical movement of landfast ice due to tides or storm surges have been noted by local residents. Frank Long, Jr. stated, *"If there's enough water that comes in, it'll bring the ice up, plus water will be flowing over up over the edge..."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8). According to Thomas Napageak, *"...When the tide comes, these chunks of ice that are...frozen [in place], the ice breaks around them, and...that's where the water comes out."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8).

Pressure Ridges/Shear Ice Zone: Inupiat residents report that ice movement is much more dangerous in the deeper, faster moving waters offshore of Cross and Northstar Islands, than inshore of Seal Island and the barrier islands (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2), due to active ridge formation in the shear ice zone. Ice coming from the north forming pressure ridges is not considered as dangerous as ice which moves from side to side, particularly from southwest to east, like the ice that moved the barges in the example given above (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2).

Henry Nashaknik, a Barrow elder, stated, *"...These big pressure ridges which have been grounded on the ocean bed, when these become grounded in shallow water, they call them kisitchat."* (NSB, 1981:414). In testimony gathered during the Diapir EIS, Joash Tukle of Nuiqsut warned that pressure ridges form up to 20 ft (6 m) high in some areas (USDOI, MMS, 1982:5). The correlation between ridge formation and wind has been observed by Otis Ahkivgak, a Barrow elder, *"The ice beyond the islands is unpredictable; even though it's frozen thick, it forms large pressure ridges when it's windy in any direction."* (NSB, 1980:100). Thomas Napageak noted that the pressure ridges are higher following winters when the polar ice pack is further out to sea (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:11).

Leads: The formation of open leads in sea ice is important to the Inupiat with respect to ice movement and open water hazards, as well as ease of travel over the ice. Leads are unpredictable and appear in different places every year. They also open and shut quickly, which is the primary reason why there is no spring whaling season in Nuiqsut (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). Bernice Pausanna of Nuiqsut stated: *"When you're out on the ice, everything happens real fast, and anything can happen in less than two, three minutes. When you're out on the ice, when the wind changes, opens a crack, then you have an open lead all of a sudden. Then you have to pack everything and go to safe ice. It happens real fast, even closing."* (USDOI, MMS, 1995:41).

Wind causing leads to open also was noted by Elijah Kakinya in the following account: *"...westerly wind usually opened the lead. There's a break before it gets real frozen in. When the wind shifts over to a northeasterly wind, it moves on the shore ice. The ice usually crumbled up and formed some pressure ridges way out on the edge of the lead."* (NSB, 1980:152).

During the fall whaling season, hunters often look for leads as a travel pathway. Henry Nashaknik stated: *"I know people from Napaqsralik [Cross Island, who]...hunted on open leads. When the wind is from the west, the leads would open."* (NSB, 1980:152). Frank Long, Jr. observed, *"...During the fall when we're out on ice, heavy ice conditions, there are...leads that open up."* (USDOI, MMS, 1995:24). Leonard Tukle, a Nuiqsut whaling captain, recalled: *"I remember one time when there was heavy ice all the way along the coast, we had to come...pretty close to the rig [near Seal Island]...for driving out for open water. The only open lead that we had was around that rig at one time. I think this was in '91 or '92."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:17).

Open Water Floe Movement: Inupiat residents noted the following with respect to the occurrence and movement of ice floes during the open water season. According to Walter Akpik, Sr., of Barrow: *"The ice moves out on the ocean side of the islands and the mainland; goes out towards the ocean during the spring breakup in between the islands. The ice from the ocean [polar ice pack] hardly ever gets inside the bays. Sometimes there might be a piece in there now and then. The bays are clear of ice by the middle of summer."* (NSB, 1980:106). Elijah Kakinya noted: *"In some years when the ice goes out in spring, it isn't visible in summer. Some years the ice goes out and comes back and is visible, and hangs around all summer months."* (NSB, 1980:152). Harry Akootchook of Kaktovik indicated that the ocean currents are strong in that area, with big icebergs (USDOI, MMS, 1982:5).

Inupiat residents speak of the movement of ice floes as being controlled primarily by wind direction. Elijah Kakinya stated: *"In summer months, when there is a westerly wind, you can see ice from shore. But when the wind is blowing from northeasterly, the ice always goes out...you can't see any ice from shore."* (NSB, 1980:152). Henry Nashaknik, who has hunted for several decades in the vicinity of Cross and McClure Islands and the Colville and Sagavanirktok Rivers, provided similar observations: *"...when the wind is constantly from the east in the summer months, all the ice goes out seaward of these barrier islands. The coastal ice [also] goes out when the wind is from the west, but even when the wind is strong and constant from the west, the ice seaward of the barrier islands is still visible. Only when the wind changes from west to east does it [ice floes] finally go out completely."* (NSB, 1980:152). Bruce Nukapigak, a Kaktovik elder, observed: *"The pieces of polar ice come in through the bay between Return Islands and Midway Islands; this is...when the strong winds are from the west. When there is little wind, the currents really play with ice along there."* (NSB, 1980:174).

The movement of ice floes through barrier island channels due to tides or storm surges was noted by Bruce Nukapigak: *"...In summer months and at Pinu, Bodfish and Cottle Islands, the pieces of ice move in and out through the channels with the tides. The polar ice gets pushed in from the ocean just west of Napaqsralik [Cross Island] to Beechey Point. There is no strong current on the ocean side of the islands,...but the ice in places with "singaq" [channels] are controlled by the tidal currents."* (NSB, 1980:174).

5.2.4.4 Ice Pile-Up and Ride-Up

The force and speed at which ice moves during the fall season, potentially causing override situations, is of great concern among the Inupiat people. Whaling captains observe that the polar ice pack "crunches up" young (first-year) ice that is 1 to 2 ft (0.3 to 0.6 m) thick with great speed and force (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). This hazardous condition typically results from a combination of storm, current, tide, and ice conditions, particularly under a southwest wind, according to Thomas Napageak (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). Otis Ahkivgak, a Barrow elder, spoke about the wind being the main controlling force behind major ice override events (NSB, 1981:100). Kaktovik residents indicated that these powerful ice movements can occur even without the contributing factor of wind, because the currents in that area are extremely strong and swift (H. Rexford in USDOI, 1979:49; J. Ningeok in USDOI, MMS, 1990:19-20).

Numerous reports of extreme pile-up and ride-up events have been documented through testimony and transcripts. Phillip Tikluk, Sr. of Kaktovik described the ice piling up on a 30- to 40-ft (9 to 12 m) cliff by Kaktovik one June, depositing 5 to 6 ft (1.5 to 2 m) of ice on top of the cliff (USDOI, MMS, 1979:4). A similar event was reported by Archie Brower at Bullen Point in the vicinity of Flaxman Island, located approximately 40 miles (64 km) east of the project area: *"I saw how a garage that was about 30 ft (9 m) above the water line on the coast had been destroyed by ice.... Ice had piled up...from both the east and the west."* (USDOI, MMS, 1979:4). In a description of possibly the same incident at Bullen Point, Thomas Napageak and Archie Ahkiviana both indicated that the garage was located inland approximately 50 to 100 ft (15 to 30 m), and that the force of the ice bent a steel H-beam in the garage, popping 1-inch (2.5 centimeter [cm]) bolts out of the cement (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:9). A Nuiqsut elder described an incident that happened in the 1940s on one of the offshore islands in the area (possibly Cross Island), where a family was camping and ice moved onto their tents as they slept, killing them (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). Hugo Engel of Barrow reported that he witnessed huge, massive pieces of ice taking down utility poles during an extreme override event (USDOI, 1982:86). Warren Matumeak, also of Barrow, indicated that he had seen ice override a 20-ft (6 m) bluff at the far end of town (USDOI, MMS, 1982:92). Charles Edwardsen of Barrow recalled a situation where ice destroyed a manmade structure (USDOI, MMS, 1982:22).

Inupiat residents have remarked on the speed at which ice override events can occur, as well as how rapidly ice conditions can change. Archie Brower of Kaktovik reports: *"The ice conditions are very changeable. Unusual storms can come up at any time, and if wind and currents combine in certain ways, the ice destroys structures on or near the ice pack."* (USDOI, MMS, 1979:4). Several Kaktovik hunters described these ice events as occurring very rapidly, allowing little time for response (J. Ningeok in USDOI, MMS, 1990:19-20; H. Rexford in USDOI, MMS, 1979:49; P. Tikluk in USDOI, MMS, 1979:49).

Information regarding ice override at barrier islands and along shorelines inshore of barrier islands are found in several sources of Traditional Knowledge. Bruce Nukapigak, an 18-year resident of the Siklaqtitaq (Point McIntyre) and Beechey Point areas, indicated: *"The ice piles up along the coast outside* *of the barrier islands [at Beechey Point]...[and that he's] never seen big piles like you get at Utqiagvik [Barrow]."* (NSB, 1980:174). Walter Akpik, Sr. stated: *"I have seen the ice pile up on the side of the barrier islands, but never covering them completely. During our first winter at McClure Island, the ice was moving and piling up so high, that some ice broke off the top and almost hit our house. This island is not very wide and our house was in the middle of the island, and that piling ice just barely missed reaching it."* (NSB, 1980:106). Elijah Kakinya, a resident of Flaxman Island, reported: *"...on the lagoon side...after the ice formed and froze, it never moved or made any disturbance...in fall, the ice usually crumbled up and built ridges along barrier islands...I never noticed any ice slide over the barrier islands...when the ice crumbled up along the ocean side of the barrier islands, the highest points...were approximately 12 to 15 feet high."* (NSB, 1980:152). Archie Brower reported that during years in which the ice is thin in the winter, it can, *"...override even high coastal bluffs in areas that are inside the barrier islands"* (USDOI, MMS, 1979:4). In addition, the ice at times has pushed from the ocean side of the Kaktovik airport road to the lagoon side, blocking the road (A. Brower in USDOI, MMS, 1979:47-48).

The many years of observation by Inupiat residents include occasional extreme events. Isaac Akootchook of Kaktovik gave an example of the necessity for considering many years of data to predict extreme events, when he described ice that piled up as much as 40 ft (12 m) high at the shore in this area, adding, *"... but for many years - maybe 50 years now - we haven't seen [it that high]."* (USDOI, MMS, 1982:3). Nuiqsut whaling captains questioned the scientific concept of a 100-year event, particularly as a severe event that only happens once every 100 years. They indicate that it could happen more frequently and during any year and that they never know when (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). However, Nuiqsut residents generally were less concerned about dangerous ice conditions near Seal Island, which is in a more stable nearshore zone, compared to greater hazards near Northstar Island, which is near the shear ice zone (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

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5.3 GEOLOGY AND HYDROLOGY

5.3.1 Affected Environment

Active geologic and hydrologic processes contribute to the development and continual modification of both the onshore and offshore physical environments. These factors, in combination with climatic and oceanographic conditions, have resulted in unique physical characteristics, including a partially relict (having survived from an earlier era) shoreline, onshore and subsea permafrost, and permafrost-related thaw features. "Hydrologic environment" in this section refers to onshore surface water and groundwater. Marine waters are discussed in Section 5.5.

5.3.1.1 Physiography and Landforms

The onshore portion of the project area is located on the Arctic Coastal Plain. The coastal plain is within the zone of continuous permafrost and has flat to rolling terrain with many shallow ponds and lakes (Figure 5.3-1). The coastline consists of beach bluffs, bays, spits, and bars. Deltas form along the coastline at the mouths of large rivers, such as the Kuparuk, Colville, and Sagavanirktok.

The ground surface over most of the flat thaw-lake plain varies by less than 6 ft (1.8 m), except at pingos, which may reach 60 ft (18 m), and along banks of the larger streams (Walker and Acevedo, 1987:3). Low-centered and high centered ice wedge polygons, geometric topographic features caused by ice formation in soil and subsoil, cover most of the project area and all four of the onshore pipeline routes considered in this

Figure 5.3-1 (page 1 of 2)

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EIS. The gravel source for the reconstruction of Seal Island is located within the floodplain near the mouth of the Kuparuk River.

The coastline within the project area contains numerous spits and barrier islands formed by longshore currents. The shallow nearshore area is semi-enclosed to the north by these low barrier islands (Figure 5.3-1). The barrier islands are composed mostly of sand and gravel; however, some parts are submerged remnants of a once more extensive coastal plain. The bluff at the Point Storkersen landfall (Alternatives 2 and 3) ranges in height from 3 to 4 ft (0.9 to 1.2 m) (CFC, 1996:4). The landfall for Alternative 4 is located in an intertidal area with a shallow sloping shoreline. Alternative 5 intercepts the manmade West Dock gravel causeway. Several other offshore features have been built in the project vicinity including Seal Island, Northstar Island, and the Endicott causeway and islands.

5.3.1.2 Regional Geology

Structurally, the project area is dominated by the effects of Jurassic and Early Cretaceous rifting (Plafker and Berg, 1994:17). The period of rifting (pulling apart) resulted in the formation of the Canada Basin, an ocean basin which lies northeast of the central Alaskan Beaufort Sea shelf. A generalized stratigraphic column (diagram showing subsurface rocks) for the project area is presented on Figure 5.3-2. Metamorphic rocks (of Silurian and Ordovician age) form the deep basement complex in northern Alaska. These rocks are overlain by a series of sedimentary rock units which range in age from Devonian to Quaternary.

The Northstar reservoir is located along the north side of the Barrow Arch within the Triassic age Ivishak formation, which is part of the Ellesmerian sequence (BPXA, 1996b:3-1; BPXA, 1997:Table 3.6-1). The oil reservoir is at a depth of approximately 10,839 to 11,100 ft (3,304 to 3,383 m), and generally is situated beneath the manmade Northstar and Seal Islands (Figures 4-2, 4-3, and 4-4). The Northstar oil deposit exists because impermeable rocks overlying the Ivishak formation are folded downward and form a trap (Figure 4-3).

Two proposed waste injection zones (for disposal of produced water, drilling wastes, surface runoff, and domestic and/or sanitary wastes generated from the project) are depicted on Figure 5.3-3. Details of the waste injection process and receiving formations are presented in Appendix A. The zones lie at approximate depths of 4,000 and 4,700 ft (1,219 and 1,433 m) within sandstones of the upper Cretaceous-age Prince Creek/Ugnu formation (BPXA, 1997:Table 3.6-1). Waste injection zones are located beneath a low permeability confining zone within the Tertiary-age Sagavanirktok formation, and above a low permeability shale barrier within the upper Cretaceous-age Seabee formation. The upper and lower barriers isolate both waste injection zones from the formations above and below, including the oil producing unit. These injection zones and upper and lower confining layers are the same units successfully utilized for waste disposal at the Prudhoe Bay and Duck Island units (BPXA, 1997:Appendix A). Appendices J and N contain the draft and final Underground Injection Control permits, respectively.

Seismicity within the North Slope region is relatively low. Seventy-three earthquakes were recorded along the Arctic Coast from Point Barrow to the Canadian Border between 1937 and 1992. The magnitude of the earthquakes ranged from less than 1.0 to 5.3 on the Richter Scale, and most were centered in the Camden Bay region, located approximately 80 miles (129 km) east of the project area. There are no records of any damage to facilities at Prudhoe Bay resulting from these events.

Shallow faults are known to occur along the Alaskan Beaufort Sea shelf outside the project area. These faults have been reported northwest of Milne Point associated with the Barrow Arch and offshore of Camden Bay (Craig et al., 1985:152). Although it is possible that additional high resolution seismic surveys could show more shallow faults within the project area, there are no major faults on the Northstar reservoir formation at the depth of the waste injection zones (BPXA, 1997:3-2).

The presence of shallow gas has been observed on high resolution seismic data collected from Stefansson Sound within the project area (Craig et al., 1985:161-163). Shallow gas has been mapped near Endeavor Island and offshore of Midway and Cross Islands (Craig et al., 1985:Figure 47). However, the four exploration wells drilled at Seal Island did not encounter shallow gas deposits.

Subsurface gas can also occur in marine environments in the form of gas hydrates (solids composed of ice and gas). Gas hydrates tend to cement the sediment, creating a zone of reduced permeability at their base that may act as a trap for free gas (Grantz et al., 1982:29). Gas hydrates typically occur near the seafloor under low temperature and high pressure conditions of the Beaufort Sea in water depths exceeding approximately 1,000 ft (305 m) (Grantz et al., 1982:29). Gas hydrates are also known to occur at shallow depths onshore in the Prudhoe Bay area where permafrost conditions exist (Kvenvolden and McMenamin, 1980:1-3). Based on geophysical data collected across the Beaufort Sea shelf, gas hydrates are estimated to occur in the Northstar Unit at depths ranging from approximately 2,953 to 4,921 ft (900 to 1,500 m) (Collett - Pers. Comm., 1997:2).

5.3.1.3 Permafrost

Permafrost is defined as ground that remains at a temperature below 32 degrees Fahrenheit (°F) (0 degrees Celsius [°C]) over a period of many years. Permafrost is present throughout the project area, both onshore and offshore. Permafrost is present along the Arctic Coastal Plain from very near the surface to

Figure 5.3-2 (page 1 of 2)

Figure 5.3-2 (page 2 of 2)

Figure 5.3-3 (page 1 of 2)

Figure 5.3-3 (page 2 of 2)

depths ranging from approximately 656 to 2,133 ft (200 to 650 m) (Lachenbruch et.al., 1988:647). The depth of seasonal thaw (active layer) varies with specific soil conditions, but in undisturbed dry areas is generally about 1 to 2 ft (0.3 to 0.6 m) and rarely exceeds 3.5 ft (1 m) in wet soils (Rawlinson, 1983:4-7).

Thaw bulbs are permanently unfrozen soils found in permafrost and are likely to be present within the project area below lakes and river channels and in areas disturbed by human activities (Rawlinson, 1983:4-7). Within these thaw bulb areas, engineered facilities are susceptible to the effects of frost heave and frost jacking.

Permafrost in the offshore environment formed when portions of the Alaskan Beaufort Sea shelf were exposed to the Arctic climate during periods of lower sea levels. It is believed that permafrost formed to depths of 1,000 ft (305 m) beneath the exposed shelf, then partially melted during later periods of higher sea level (Craig et al., 1985:146). The existence of subsea permafrost is dependent on several other factors as well, including seawater temperature and salinity, lithology, and the extent of shorefast ice in winter.

Offshore permafrost in the project area consists of either unbonded or ice-bonded (Figure 5.3-4) frozen ground overlain by an active layer of seasonally thawed sediment. In the offshore environment, unbounded permafrost consists of sediments with temperatures below 32° F (0° C) that exhibit no interstitial pore ice bonding. In these sediments, the salinity of the seawater within the interstitial pores inhibits ice formation due to the depressed freezing points of the highly saline waters. Seafloor sediment is often unbonded due to this salinity effect (Rawlinson, 1983:6). Lithology soil type can also control the distribution of bonding in offshore sediment, as evidenced by grain size and organic content variations in borings drilled by Miller (1996:Appendix A) (Figure 5.3-4). Ice-bonded permafrost occurs when the sediment is held together by interstitial ice so that it is relatively resistant to chipping or breaking. Ice-bonded sediments in the offshore area are mostly relicts of permafrost formed during subaerial exposure when the sea level was lower.

Data gathered from borings drilled in the project area show that the depth to ice-bonded permafrost varies in the offshore environment (Figure 5.3-4). Recent borings drilled in the project area generally encountered ice-bonded sediments between the shoreline and Stump Island at depths ranging from 1 to 33 ft (0.3 to 10 m) (Miller, 1996:Plate 2, Appendix A).

Offshore zones of icebonded permafrost are located in Simpson Lagoon between the coastline and approximately 2,200 ft (671 m) from shore, and between 3,800 ft (1,158 m) from shore and 2,000 ft (610 m) offshore of the barrier islands. Data for the area offshore of West Dock show an abrupt dip in the depth of ice-bonded permafrost close to the present day shoreline (Rawlinson, 1983:7; Craig et al., 1985:148). Between approximately 1,312 and 1,608 ft (400 to 490 m) from shore near West Dock, the depth to ice-bonded sediment increases abruptly from approximately 10 ft (3 m) to approximately 65 ft (20 m), corresponding roughly to the limit of shorefast ice in winter (Osterkamp and Harrison, 1976:16).

The depth to ice-bonded permafrost at Seal Island is approximately 300 ft (91 m) (BPXA, 1996b:Exhibit 3-2). No ice-bonded sediments were encountered in any of nine soil borings drilled within the project area near Northstar Island, although sediment temperatures of less than 32°F (0°C) were reported, indicating the presence of unbonded permafrost (Musial and Nidowicz, 1984:6).

Barrier islands in the project area are underlain by permafrost (Rawlinson, 1983:8). Two site investigation boreholes drilled on Stump Island showed ice-bonded permafrost between the surface and the maximum depth of drilling at 36 ft (11 m). On Reindeer Island, in the northeast portion of the project area, well data indicates the presence of two layers of permafrost at depths of approximately 0 to 62 ft (0 to 19 m) and 299 to 420 ft (91 to 128 m) (Craig et al., 1985:149). The deeper layer of permafrost is believed to be quite old, while the shallower layer is believed to have developed under modern arctic conditions.

Ice lenses may be present within both bonded and unbonded subsea permafrost in the project area. Ice lenses are normally about 1/4-inch (0.6 cm) thick, but occasionally form to 18 inches (46 cm). Ice lenses have been reported in offshore sediment in Stefansson Sound and Mikkelsen Bay at depths of up to 300 ft (91 m) below the seafloor (Miller and Bruggers, 1980:329).

5.3.1.4 Terrestrial Soils

Soils in the project area generally consist of poorly drained silty to clayey loams and peats. Floodplains have gravelly to sandy soils (Rieger et al., 1979: Sheets 2 and 3). Thickness of the vegetative mat varies with soil type, as does the ice content of frozen soils. Thick permafrost underlies these soils, and frost-patterned ground is common. Onshore soils in the southcentral portion of the project area generally include a very wet, 2- to 12-ft (0.6 to 3.7 m) thick, organic mat or silt layer underlain by brown sand with minor silt and gravel, or silty gravel (Dames & Moore, 1989:2; 1991:4; Walker et al., 1980:9). Organic soils in this area are ice-rich, containing approximately 25 to 30 percent (%) visible free ice, while the sandy soils contain less than 5% visible ice.

5.3.1.5 Offshore Sediment

Seafloor deposits within the project area generally consist of muddy sand and sandy mud with minor amounts of gravel (Barnes and Reimnitz, 1974:457 and 458). The deposits primarily include very stiff, silty clay inshore of the barrier islands, and stiff silts offshore of Long, Egg, and Stump Islands at water depths of about 5 to 10 ft (1.5 to 3 m) with scattered gravels and cobbles throughout. The silts are generally highly over-consolidated due primarily to freezing and thawing cycles (Reimnitz et al., 1980:1).

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Geotechnical borings drilled in the project area (Figure 5.3-5) provide information on sub-bottom sediment units (Table 5.3-1). Several borings drilled inshore of the barrier islands encountered 15 to 25 ft (4.6 to 7.6 m) of fine-grained sand and silt, overlying sand and gravel (McClelland-EBA, 1985:5-6; Miller, 1996:Plates 1 and 2). Borings drilled in the area between West Dock and Stump Island encountered a layer of fine-grained sediment to depths of 5 to 23 ft (1.5 to 7 m) below the seafloor, underlain by coarser sediments (McClelland-EBA, 1985:6). Surface sediment encountered between Egg and Stump Islands generally consisted of sand and silt.

Although these geotechnical borings are generally along the proposed offshore pipeline routes, it is important to note that no geotechnical boring program has been completed directly along the complete length of any of the action alternatives (Alternative 2 through 5). In particular, for the shoal zone between Egg and Stump Islands where considerable differential thaw settlement could potentially occur, the two borings taken in this general area are spaced more than 1,000 ft (305 m) apart (PS-1 and McE-16, Figure 5.3-4) and are 700 to 800 ft (213 to 244 m) to the east of the offshore pipeline route for Alternatives 2 and 3. Hence, these borings provide limited site-specific information. This was substantiated by independent review by the U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (see Appendix P for additional details).

Four categories of sediment have been identified based on borings located offshore of the barrier islands (Miller and Bruggers, 1980:327; Miller, 1996:Plate 2, Appendix A). These include: soft to medium stiff, fine-grained deposits; medium dense to very dense, uniform fine-grained sand; stiff to hard silt and clay deposits; and dense sand and gravel. Boring logs in the area offshore of Stump Island generally indicate a thick sequence of sands and gravels starting at 10 to 35 ft (3 to 10.7 m) below the seafloor, overlain by a younger layer of fine-grained sand and silt. The buried or sub-bottom depth to the top of the sand and gravel unit in the project area generally increases from nearshore to offshore, and from west to east. Borings drilled offshore of the barrier islands in the vicinity of Seal and Northstar Islands indicate similar sediment conditions to those further inshore (Table 5.3-1).

Geotechnical analyses conducted to assess the suitability of seafloor sediment with regard to trenching indicated that sediments in an ice-bonded condition can support high loadings, but silts and unbonded sediments are susceptible to settlement (HLA, 1979:82; WCC, 1981:3-7; Miller, 1995:3-6, Plate 5). The slope stability of shallow sub-bottom sediment was studied during a test trenching operation in March 1996 (INTEC, 1996e:4; 1996g:2-4; 1997c:4). Frozen silts in contact with bottomfast ice in Simpson Lagoon held vertical sidewalls with very little slumping. At another site where the sediments were frozen to partially frozen and there was water beneath the ice sheet, sidewalls slumped after several hours. In approximately 16 ft (4.9 m) water depths offshore of Stump Island, where sediments are composed of 5 ft (1.5 m) of unfrozen silt overlying sand, vertical test trench sidewalls were maintained to the 5 ft (1.5 m) depth, until sand slumping beneath this layer caused the silt walls to slump.

Table 5.3-1 (page 1 of 1)

Figure 5.3-5 (page 1 of 2)

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Sediment chemistry in the project area, including parameters such as total organic carbon (TOC), trace metals, and hydrocarbon content, is affected by sediment transport processes (Section 5.3.1.6). Primary sediment sources in the marine environment, including riverine input of suspended material and erosional transport of mainland shoreline peat and tundra vegetation, contribute large amounts of organic carbon, hydrocarbons, and trace metals to the subsea sediments (Boehm et al., 1990:1-11).

Sediment sampling and analyses in the Alaskan Beaufort Sea region has focused on hydrocarbons and trace metals because of their association with oil and gas activities. Recent sediment quality information comes from site-specific monitoring efforts performed in conjunction with oil and gas development activities, such as those at the Kuparuk, Endicott, and Prudhoe Bay oil fields. Sediment quality data was collected on the trench sediment samples discussed above and along the offshore pipeline route (Montgomery Watson, 1996:10-12; 1997). Sediment quality monitoring stations are shown on Figure 5.3-6 and sediment chemistry results are presented in Table 5.3-2 (WCC, 1996:1-9).

TOC is a parameter sometimes used to quantify sediment mixing (disturbances). A higher TOC value may indicate higher rates of deposition and, therefore, little mixing by benthic invertebrates. Conversely, a lower TOC value indicates greater mixing of sediments. TOC at Alaskan Beaufort Sea monitoring stations from 1984 to 1986 ranged from 3.4 to 18 parts per thousand (ppt) (Boehm et al., 1987:6-20, 6-21). TOC values ranged from 0.7 to 30 ppt at 49 monitoring stations sampled during the 1989 sampling program, 39 of which had been sampled previously in the 1984 to 1986 studies (Boehm et al., 1990:4-35). TOC values for test trench sediment samples ranged from 6.3 to 26.3 ppt for the Simpson Lagoon location, and 4.6 to 40 ppt for the location offshore of Stump Island (Montgomery Watson, 1996:Table 4). Higher TOC values were generally found near river deltas.

Alaskan Beaufort Sea sediment analyses have focused on those metals likely to increase due to the presence of oil and gas development activities. For example, barium and chromium are components of drilling muds, and vanadium is a constituent of the petroleum combustion process. There is considerable variability in trace metal concentrations in Alaskan Beaufort Sea sediment, including seasonal variations (USACE and ERT, 1984:3-39, 3-44). It appears some metals (barium and cadmium) increase with the influx of sediment from local rivers during the open water season each year, and decrease during winter.

Hydrocarbons found in Alaskan Beaufort Sea sediments primarily are naturally-occurring compounds resulting from riverine and other onshore sources rather than from human activities. Hydrocarbon compounds are dominated by waxy plant material (peat) and fossil fuels (coal and oil). Hydrocarbons found in nearshore and offshore sediments show little evidence of anthropogenic (caused by human activity) petroleum inputs (Boehm et al., 1990: 5-69). The results of chemical analysis for fuel products from a 1995 sediment sampling program in the project area are presented in Table 5.3-2 (WCC, 1996:7-9).

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Figure 5.3-6 (page 1 of 2)

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5.3.1.6 Erosion and Sediment Transport

Coastal erosion within the project area results in constant change to the shoreline. Waves, storm surges, and thermal degradation, such as thaw bulbs or melting ice lenses, can result in dramatic erosion and shoreline retreat. In addition, extremely strong currents moving across the inner shelf during these surges deeply erode the shoreline and barrier islands. Erosion rates are highest along coastal points and bluffs composed of fine-grained soil and ice lenses (Grantz et al., 1982:35).

Local coastal erosion rates within the project area were evaluated by reviewing historic aerial photographs for the years 1949 through 1996. Based on measurements averaged along eight different segments of the coastline (Figure 5.3-7), it appears to be retreating at rates ranging between 0.8 and 9.8 feet per year (ft/yr) (0.2 and 3.0 m/yr). The rates of erosion tend to vary substantially depending on the location of barrier islands and manmade structures, local lithology, and shoreline morphology (structure and form). The highest individual measurements of shoreline retreat were located near the west side of the base of West Dock where an erosion rate of 9.8 ft/yr (3 m/yr) was calculated over a 40-year period (Figure 5.3.7). It appears that the presence of West Dock since the early 1980s has affected longshore sediment transport (to the west) such that loss of sediment along the lee (i.e., west side) of the West Dock causeway is not being replenished. The next highest measured coastal erosion rates, which are expected to be representative of current conditions, are between Point Storkersen and near the unnamed point east of the nearby Distant Early Warning Line site. The least erosion occurred right at the site (0.8 ft/yr [0.2 m/yr]), where historic stabilization activities may have kept shoreline retreat in check. Similar erosion rates were calculated by other researchers. Measured retreat rates west of Gwydyr Bay range from 3.6 to 4.1 ft/yr (1.1 to 1.2 m/yr) (Leidersdorf and Gadd, 1996:4). Average shoreline retreat rates of 4.6 ft/year (yr) (1.4 m/yr) for the section of shoreline between Oliktok Point and Prudhoe Bay, and 9.8 ft/yr (3 m/yr) for a 20-mile (32 km) section of coastline east of Prudhoe Bay have been reported (Hopkins and Hartz, 1978:19).

Barrier islands within the project area act as a buffer against weather, ice, and waves with respect to the mainland shoreline. Their presence results in a low-energy environment and more stable onshore conditions. Barrier islands lying within the project area include Stump, Egg, Long, and Cottle Islands, of the Return Islands chain; and Bodfish and Bertoncini Islands of the Jones Islands chain. These islands form an elongated band parallel to the present coastline, approximately 0.5 to 2.5 miles (0.8 to 4 km) from shore (Figure 5.3-1). Barrier islands typically are depositional features; however, parts of the islands in the project area are believed to be sections of the former mainland shoreline which were isolated from the mainland during the last sea level rise (Rawlinson, 1990:19). The shape, location, and orientation of the remnant shoreline sections suggests they may represent the edges of former thaw lakes, connected by recently deposited sediment.

Within the project area, barrier island shape, size, and location is controlled by sediment transport and deposition, and the presence of stationary sections of submerged remnant shoreline. Currents along the coastline result in a net westerly sediment transport. The result is island extension rather than migration.

Barrier islands within the study area have extended toward the west at an average rate of 35 to 40 ft/yr

(10.7 to 12.2 m/yr) from 1955 to 1995. The approximate change in configuration of Stump and Egg Islands over a 40-yr period is shown on Figure 5.3-8. The islands are breached periodically, presumably during storm surge events. In some cases, the breaches appear to be self-healing as a result of a steady supply of sediment carried by longshore currents and deposited along the stationary sections of remnant shoreline.

Sediment erosion and transport between the shoreline and approximately the 66-ft (20 m) water depth generally are caused by wind-generated waves, currents, and sea ice, which gouge the seafloor causing resuspension of bottom sediments. Ice also dampens currents and waves, slowing sediment transport. Winter tends to be an inactive period, while summer is an active period for sedimentary processes (USACE and ERT, 1984:3-32).

Average sedimentation rates in the nearshore portion of the Alaskan Beaufort Sea shelf generally are about 1.6 ft (0.5 m) or more of deposition per year, although subsequent erosion removes some or all of the material deposited (USACE and ERT, 1984:3-37). Sediment is supplied to lagoons from river outflow (Boehm et al., 1990:1-11). The project area is offshore of the Kuparuk and Sagavanirktok River Deltas and is affected by flow from these systems. Erosion of tundra bluffs and beach areas also results in sediments entering the marine environment. The Kuparuk River reportedly discharges about 4.4 times the amount of sediment to the marine environment as that coming from coastal erosion in the project area (USACE and ERT, 1984:3-32). However, dramatic rates of erosion can also result from degradation of coastal permafrost. At Oliktok Point, located about 9 miles (14.5 km) west of the project area, the coast receded 35 ft (10.7 m) during one 2-week period (Hopkins and Hart, 1978:28).

Wave action and longshore currents are important mechanisms for the transport of sediment within the project area. Longshore currents erode and transport large amounts of beach sediment. Studies conducted at Egg Island indicate that an average of 110,000 cubic feet (ft^3) (3,115 cubic meters [m^3]) of beach sands are transported annually by longshore currents (USACE and ERT, 1984:3-32 through 3-34). Wave action and currents are described further in Section 5.5.

Wind-blown material also may contribute to soil and sediment deposition within the project area. Wind action during winter has been observed to create plumes of sand on top of landfast ice downwind of several barrier islands. Observations made at Egg Island indicate that approximately 7,100 ft^3 (201 m^3) of sand were eroded from the island by the wind during a single winter (USACE and ERT, 1984:3-32).

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Figure 5.3-8 (page 1 of 2)

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Ice effects such as gouging, ice push, strudel scour, and entrainment by freezing can act as mechanisms for erosion and transport of marine sediment in the project area. Ice gouging is identified as one of the most important processes of sediment reworking on the Arctic continental shelf, particularly at mid-shelf and inner-shelf water depths (Craig et al., 1985:124). Ice push and ice override events along the coastline can erode and transport large amounts of nearshore and coastal sediment into ridges further inland. This process is most important on the outer barrier islands (Craig et al., 1985:128). Strudel scour causes holes in the seafloor sediment when landfast sea ice is overflowed by river floodwaters, which flow through holes or cracks in the ice creating depressions in the seafloor by erosion. Additional details on the destructive or erosional effects of these processes are presented in Section 5.6.1. Sediment also can be frozen in sea ice and then transported as the ice moves. Large quantities of sediment may be captured in sea ice as it freezes to the seafloor. It has been estimated that an average of approximately 6,400 ft^3 (181 m^3) of sediment may be present in each square mile (2.6 square km [km^2]) of sea ice (USACE and ERT, 1984:3-32 through 3-34).

5.3.1.7 Onshore Hydrology

Onshore hydrologic conditions have a strong influence on both the onshore and offshore physical environments of the North Slope. River discharge is the major source of sediment input to the marine environment. Onshore water quality, river flow, and sediment load affect marine water quality in the nearshore region. River flow during breakup is an important factor in nearshore seabed erosion (strudel scour) (Section 5.6.1.4). Surface water bodies cause thaw bulbs and other permafrost features in the onshore permafrost (Section 5.3.1.3), which in turn affects the distribution of surface vegetation. The arctic hydrologic environment is influenced by severe climate, seasonal frost and associated permafrost, and flat topography. Severe arctic conditions, including below freezing temperatures throughout most of the year and continuous permafrost, cause wide fluctuations in runoff and stream flow.

Surface water flow (sheet flow) outside existing streams typically occurs on the North Slope between early May and mid- to late September (Hinzman, 1989:35-36). The presence of shallow permafrost limits the infiltration of water through the soil, and a perched water table within the active layer develops. Surface water flow is generated when the suprapermafrost (above the permafrost) water table rises above the ground surface. Saturation of the active layer and filling of depressions in the ground surface must occur before surface runoff can begin. Project design features, such as the elevated pipeline (onshore segments) and the use of ice roads, will not create any impediment to surface water flow.

Thaw lakes are a dominant onshore feature in the project area, and are often used as a source of freshwater for ice road construction. They are formed by localized thawing of the upper permafrost by ponded water and range in depth from less than 3 to 20 ft (0.9 to 6.1 m) (USACE and ERT, 1984:3-38). Localized thawing of the upper permafrost can be caused by removal of the organic cover. A thaw lake may develop if the disturbed area collects surface water. The body of water expands by thawing permafrost below the water level and undercutting the surrounding tundra. The position of the lakes generally is perpendicular to the dominant wind direction because the wind increases undercutting of the soil. Continuation of these processes results in the lake shorelines migrating in the direction of prevailing winds (USACE and ERT, 1984:3-38).

Lake water generally has lower total dissolved solids than stream water, but may have a dark color and/or odor, distinctive of a high iron content plus tannic acid from peat. Lakes less than 6 to 10 ft (1.8 to 3 m) deep freeze to the bottom in the winter, while the bottom layer of deeper lakes remains unfrozen throughout the year. Lakes located near the coast may have high salt levels, depending upon the amount of marine water input from storm surges (USACE and ERT, 1984:3-94).

Stream flow in the project area originates from headwater tributaries of the Brooks Range, the Arctic Foothills, precipitation, and from stored water in lakes and wetlands along the Arctic Coastal Plain. Streams and rivers in the project area are frozen for 7 to 8 months of the year (Selkregg, 1975:90). Streams originating in the Brooks Range typically have larger watersheds, such as the Sagavanirktok River, where flow may be derived from a combination of glacier-fed tributaries, surface runoff, groundwater, and springs. Streams originating in the foothills of the Brooks Range or on the Arctic Coastal Plain typically have smaller watersheds where flow is generated primarily by the melting of snow and ice, with little or no input from groundwater sources due to continuous permafrost (USACE, Alaska, 1980:F-1).

The principal drainage basins in the project area from west to east include the Ugnuravik, Sakonowyak, Kuparuk, Putuligayuk, and Sagavanirktok Rivers (Figure 5.3-1). Smaller drainages within the project area include two located near Milne Point, two between Milne Point and the Kuparuk River, Fawn Creek located between the Kuparuk and Putuligayuk Rivers, and an unnamed creek west of the Shaviovik River. Stream flow data for the two drainages (Kuparuk River for the gravel mine sites and Putuligayuk River for pipeline crossings) are presented in Table 5.3-3. A discussion of the watershed, stream flow, and water quality characteristics for the individual rivers follows.

The Kuparuk River originates in the foothills of the Brooks Range and drains an area of 3,130 square miles (8,107 km^2). Flow in this river typically peaks in early June during breakup (Scott, 1978:6-7). Mean monthly flows for the gauged basin area range from approximately 2 cubic ft per second (cfs) (0.06 cubic m per second [m^3/s]) in late winter (February through April) to approximately 11,056 cfs (313 m^3/s) in June (Table 5.3-3). Water quality and sediment discharge data for the Kuparuk River are shown in Tables 5.3-4 and 5.3-5, respectively.

The Putuligayuk River is a low-gradient, meandering river that has bed material consisting of fine gravel and stream banks of cohesive silt and clay with soil development overlying fine gravel (Scott, 1978:7). Stream flow measurements since 1970 indicate that the Putuligayuk River generally peaks rapidly, rising from near zero to peak flow during a one to two week period in early June, and falling continuously to low summer levels

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in about the same amount of time. Mean monthly flows range from 4 cfs (0.1 m^3/s) in May to a maximum of 694 cfs (19.7 m^3/s) in June (Table 5.3-3). Flows rapidly drop in July and reach zero by November. Just downstream of the Spine Road, the river is crossed by a pipeline bridge. Scour has been monitored over the life of the pipeline bridge, and the use of grout bags and rock gabions has minimized losses to the bank from scour during highwater periods. Water quality and sediment discharge data for the Putuligayuk River are shown in Tables 5.3-4 and 5.3-5, respectively.

Extensive flooding is typically associated with rivers and streams on the Arctic Coastal Plain during spring breakup between May and early July, with peak flow conditions in the first week of June. Breakup progresses rapidly, and by early July, 60% to 80% of the total annual discharge of most rivers has occurred. Ice jams and ice that is frozen to the channel bed increase the height of the floodwater during breakup in downstream river areas. The extent of river floodplains in the project area is depicted on Figure 5.3-1. Flooding subsides as the ice is broken up and melts or is carried downstream and out to sea.

Observations of water levels in rivers rising during storms have been made by both Barrow and Nuiqsut residents. A Barrow whaling captain reported that the biggest storms occur in September, causing the water levels in the rivers to rise (Pers. Comm., Barrow Whaling Captains Meeting, August 26 and 27, 1996). A Nuiqsut whaling captain reported how rising marine water levels during a storm surge can force water over the top of sea ice and flood the Colville River drainage to a distance of 18 miles (29 km) (A. Ahkiviana - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8).

River sediment output peaks with the highest river flows during June when more than 50% of the annual sediment discharge usually occurs in rivers on the Arctic Coastal Plain (Selkregg, 1975:96). Undercutting of frozen stream banks by thawing and erosion is common in arctic streams, particularly at locations of sustained high flow. The increased strength provided by permafrost in stream banks permits greater undercutting at the base of the thawed layer, which in turn produces larger slump blocks (Scott, 1978:9-11). The stream bank material becomes an important source of sediments transported by rivers.

Groundwater hydrology within the project area is affected by climate and the presence of permafrost (Sloan, 1987:241). Surface water is frozen most of the year, which limits recharge to groundwater. Addition-ally, permafrost acts as a barrier which restricts groundwater flow. Groundwater has been found beneath permafrost (subpermafrost groundwater) under most oil and gas units on the North Slope. Subpermafrost groundwater may extend within bedrock to depths of greater than 2,000 ft (610 m) below the ground surface. Groundwater contained under large streams and deep lakes that do not freeze to the bottom is a potential water supply. Subpermafrost groundwater sources, other than springs, are generally too brackish to be considered for water supply use (Sloan, 1987:241-243).

5.3.2 Environmental Consequences

The following section describes the potential impacts of each project alternative on the onshore and offshore geologic environment and the onshore hydrologic environment, including impacts to soil and sediment quality, lakes, rivers, permafrost, and deep geologic formations. Potential impacts of geologic hazards on project components (such as subsurface gas, permafrost thaw settlement, and erosion) are also discussed as they relate to four project phases (construction, operations, maintenance, and abandonment), and various project components within those phases (e.g., gravel mining and pipeline construction). The discussion of impacts is organized based on project alternatives described in Chapter 4. Discussion of Alternative 1, the No Action Alternative, is presented first. Impacts for Alternatives 2, 3, 4, and 5 are discussed together, as there are only subtle differences in impacts. Impact conclusions are the same, except where noted. Impacts are summarized in Table 5.3-6.

5.3.2.1 Alternative 1 - No Action Alternative

The geological and hydrological setting within the project area would not be affected under the No Action Alternative. The project area is naturally stressed as a result of its Arctic location and will continue to be modified by natural forces in the absence of the project. It is anticipated that coastal erosion within the project area would continue at the current rate of approximately 2.6 ft (0.8 m) per year, or approximately 39 ft (12 m) from its present position over the anticipated 15-year design life of the reservoir. Sediment transport would continue to occur in a net westerly direction along the coast and barrier islands in the project area. Seafloor features such as scour holes and undulations as a result of longshore currents and sediment transport processes within the project area would also continue to occur. Similarly, Seal Island would continue to erode, eventually to below the water surface.

The natural freezing and thawing of the active layer of permafrost would continue onshore with the slow formation of thaw lakes, pingos, and other natural physiographic features. Characteristics of onshore surface water and groundwater are not anticipated to change from the current, natural setting. Overall, no impact to the geological and hydrological environments are predicted other than those associated with natural processes.

5.3.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Gravel mining activities for Alternatives 2, 3, 4, and 5 would be conducted during a single winter. Slope stability during gravel excavation would be maintained through the use of benching and appropriate slope angles, and gravel would be hauled on ice roads constructed over both the onshore and offshore

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areas. To minimize impacts to the morphology of the Kuparuk River channel, the gravel mine has been located in a gravel deposit which is adjacent to the main river channel. After mining is completed, a 6-ft (1.8 m) deep breach will be dug on the seaward side of the pit connecting the mine site to the main channel of the river, which during spring breakup and overflow will replenish water and sediments to the mine pit through natural processes. The mine is expected to become usable fish and bird habitat once it contains water. Consequently, impacts from gravel mining on onshore geology and hydrology are anticipated to be minor.

Freshwater is required for the construction of ice roads used for hauling gravel to Seal Island for reconstruction. The volume of freshwater required for such construction varies among alternatives due to differing road lengths. Estimated total volumes of freshwater required for Alternatives 2, 3, 4, and 5 are 311, 325, 356, and 350 thousand barrels, respectively. The average of these total volumes is estimated at 335 thousand barrels, which is within 7% of each alternative estimate; therefore, freshwater requirements do not differ much among alternatives.

The required freshwater would be taken from one or more lakes permitted as freshwater sources. One likely lake is at the Kuparuk Deadarm mine site. This lake is already permitted (Permit No. ADL 75979) for removal of up to 2.38 million barrels of water per year, and is replenished each year during breakup. The volume of freshwater required for ice roads is approximately 15% of the annual amount permitted for removal from this lake. In addition, several other permitted sources are available in the project area and may be used to minimize haul distances to desired locations. To limit lake drawdown to 6 inches (15.2 cm), a lake surface of 80 to 90 acres (32.4 to 36.4 hectares) is required. Withdrawals from multiple sources would result in a drop in lake levels on the order of a few inches. Consequently, the impact to water levels would be minor.

Impacts on lakes would also include potential alterations in salinity and alkalinity. During freezing, salts are excluded from the ice. Wintertime removal of more saline water underneath the ice could result in less saline, less buffered lake waters following spring breakup (USDOI, BLM and MMS, 1997:IV-C-2). However, based on the relatively small amount of water that would be removed from these permitted lakes, this impact is considered to be minor.

During island reconstruction, sediment beneath expanded portions of the island and the protective berm would be covered with gravel, and sediment outward of the island footprint would be affected to a lesser extent by settling of suspended material. In addition, dewatering during construction would produce a sediment-laden discharge of up to 1,389 gallons/minute (5,258 liters/minute) discontinuously over a period of approximately 2 to 4 weeks. The discharged sediment is considered to be representative of background conditions, and is not expected to change existing sediment quality in the location where it settles. Consequently, the long-term impact on sediment chemical quality from this activity is considered to be negligible.

Sediment deposition during reconstruction activities would impact the seafloor in the immediate vicinity of the island. The total seafloor footprint of the reconstructed island would be approximately 18.1 acres (7.3 hectares). The footprint of the island when initially constructed was 10.7 acres (4.3 hectares)

(Agerton, 1982:Figure 2). The original island has eroded and spread out since construction to an area exceeding the 18.1 acres required for the new island's footprint. Given that reconstruction activities would be limited to this relatively small area, and would occur during a short period (3 months), the overall impact to offshore sediment quality would be minor.

Construction of the onshore pipelines for Alternatives 2, 3, 4, and 5 would require crossing various distances of undisturbed tundra. In particular, 9.6 miles (15.5 km) of undisturbed tundra would be crossed for Alternative 2 between the Spine Road and Point Storkersen. Alternative 3 would cross 6.7 miles (10.8 km) of undisturbed tundra between the Spine Road and the Central Compressor Plant (CCP) and between the West Dock Staging Pad and Point Storkersen. Alternative 4 would cross 3.5 miles (5.6 km) of undisturbed tundra between the Spine Road and the CCP and between the West Dock Staging Pad and the shore crossing. Alternative 5 would cross 3.1 miles (5 km) of undisturbed tundra between Spine Road and the CCP. None of these areas are accessible by road. These segments would be routed to avoid lakes and other water bodies as much as possible.

Since construction activities are planned for winter, soils would be disturbed only indirectly by construction traffic over ice roads and in the small footprints of the vertical support members (VSM). VSMs would be installed every 55 ft (17 m), for an approximate 1,387, 1,501, 1,166, and 1,150 VSMs for Alternatives 2, 3, 4, and 5, respectively. Approximately 6 ft^3 (0.17 m^3) of soil would be disturbed for every VSM installed. This results in a range of 255 to 334 cubic yards (yd^3) (195 to 255 m^3) of soil disturbed for Alternatives 2, 3, 4, and 5. The cuttings would be transported to the Put 23 mine site or to the newly opened Kuparuk River mine site for disposal. Impacts to soils near the VSMs depend on whether the vegetative cover is disturbed. In particular, if vegetation were removed and not replaced, thawing and exposure of the soil to erosion forces may occur (Walker et al., 1987:37-39). To prevent this, the only vegetation removed is that directly under the VSM. The slurry in which VSMs are set eliminates soil moving to fill voids between the VSM and its excavated hole. VSMs are set during winter to ensure freezing of the structure in the soil prior to summer. The resulting frozen slurry provides a solid foundation for the VSM. The overall impact to soils from construction of the onshore pipeline segments for Alternatives 2, 3, 4, and 5 is anticipated to be minor because operations would be conducted on frozen, snow-covered tundra. VSMs may also be installed on the gravel causeway for Alternative 5. No impacts to local hydrology are anticipated from either the installation or presence of these VSMs.

At the shoreline approaches for Alternatives 2, 3, and 4, soils would be excavated from an 8 ft (2.4 m) wide trench to bury the pipelines. The trench itself would be backfilled with gravel to prevent unacceptable pipeline subsidence. Native soils would then be backfilled on top of this gravel to provide a stable soil bed for revegetation. The pipeline would be buried deep enough to prevent erosion damage. The length of this onshore segment of the trench is sufficient to protect the pipeline from shore erosion over the expected life of the project because the underground structure where the pipeline transitions from the trench to the aboveground VSMs is 110 ft (33.5 m) inland of the shoreline. A gravel pad would be built at the ground surface around the pipeline transition from buried to aboveground pipeline segments. The pad footprint would be 70- by 135-ft (21.3 by 41 m) and would have a minor impact to onshore soils.

Approximately 3 to 45 ft (0.9 to 13.7 m), depending on alternative, of erosion is expected to occur during the 15-year life of the project. During the life of the project, some of this revegetated area may be subsequently removed by natural shoreline erosion. However, in the event of larger than expected erosion, some stabilizing remedial action, such as shoreline protection or nourishment (i.e., the replacement of eroded material), may be required (see Appendix P for additional data from the U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory).

Unlike the shoreline approaches for Alternatives 2 through 4, the subsea pipeline for Alternative 5 transitions to shore through a manmade gravel causeway (West Dock) as opposed to a natural beach line. Although the West Dock causeway is subject to erosion, it is regularly maintained. Hence, the shoreline approach and transition for Alternative 5 is not subject to the erosion uncertainties of Alternatives 2 , 3, and 4.

To simplify construction, onshore pipelines would be routed to avoid lakes and other water features as much as possible. The Putuligayuk River crossing would be an aboveground crossing spanning the river, with two VSM supports in the center of the span. In addition, the VSMs and their foundations would be designed to withstand the effects of river ice and floods. Other VSMs would be placed well back from the river bank to avoid shore erosion. No flow impedance is expected as a result of VSM placement either at the Putuligayuk River or across the tundra. Consequently, impacts to the onshore hydrologic environment from pipeline construction are considered to be negligible.

Installation of offshore pipeline segments for Alternatives 2, 3, 4, and 5 would occur in the winter season during which under-ice water generally is calm and sediment is less likely to be entrained. Construction activities would include excavation of a trench along the 6-mile (9.5 km) long Alternative 2 and 3 routes and the 9- and 8.9-mile (14.5 and 14.3 km) long Alternative 4 and 5 routes (Figure 5.3-5). The total volume of trench material excavated would be 264,000 yd^3 (201,828 m^3) for Alternatives 2 and 3, 380,600 yd^3 (290,969 m^3) for Alternative 4, and 377,700 yd^3 (288,752 m^3) for Alternative 5. Sediment excavated during construction of the offshore pipeline route would either be backfilled into the trench over the pipeline or disposed as excess spoil. It is expected for Alternatives 2, 3, 4, and 5 that a range of approximately 2,500 to 5,000 yd^3 (1,911 to 3,822 m^3) of excess trench spoils would be generated in the lagoon area between the coastline and the barrier islands. It is possible that up to an additional 65,000 yd^3 (49,693 m^3) of excess spoils from the lagoon area may be generated, in the event of abandonment of pipe-laying operations due to weather or ice conditions.

Excess spoils from construction of Alternatives 2, 3, 4, and 5 would be spread onto landfast ice in an area approximately 1,200 by 2,700 ft (366 by 822 m) immediately outside of the barrier islands on floating-fast ice and allowed to disperse into the water column at breakup. Initially, the settlement of excess spoils is expected to create a pile on the seafloor less than 1 to 2 ft (0.3 to 0.6 m) high. An additional area along the west side of the trench offshore of the barrier islands, about 200 by 16,600 ft (61 by 5,060 m), may also receive trench spoils from trenching activities along this deep water segment. These spoils would be less than 3 ft (0.9 m) high. Because of the dynamic nature of the Alaskan Beaufort Sea environment, the spoils disposal pile(s) are expected to erode to baseline conditions within a few years, and leave no permanent alteration of the seafloor topography. Consequently, the disposal of spoils piles on existing sediment would be minor.

The disturbance of seafloor sediments from trenching and backfilling would result in a turbid suspended sediment plume in the water column during the 3-month long activity. Settling of suspended sediment would occur along the margins of the trench, primarily in the down current direction (west). Winter season construction of the pipeline will minimize the size of the plume, as under-ice water currents are generally very low (less than 2 inches/second [less than 5 cm/second]) (Section 5.5.1.3). A maximum probable distance of under ice sediment plume transport of 830 ft (253 m) has been calculated (Montgomery Watson, 1996:7). The physical impact of plume settlement on seafloor sediment is expected to be minor due to winter construction.

Sediments which would be redeposited into the trench during dredge activities or disposed of as excess spoils are similar to undisturbed sediments and would not be expected to change existing sediment chemical quality (Section 5.3.1.5). Consequently, the long-term impact on offshore sediment chemical quality resulting from trenching activities is considered to be negligible.

For Alternative 5, the West Dock causeway area between Dock 2 and the mainland would be widened through gravel hauling and placement techniques to accommodate additional pipelines. An additional seafloor area, on the order of 5.5 acres (2.2 hectares), would be covered by gravel placement or settlement of suspended sediment. Consequently, the impact to sediment would be limited in area and is considered to be minor.

Operation Impacts: A Class I industrial waste disposal well would be used to dispose of drilling muds, cuttings, produced water, and other island wastes into confined formations lying above the reservoir rocks (Section 5.3.1.2). Disposal of waste materials in injection wells is a concern of residents, as reflected in statements made by a Barrow whaling captain, who indicated a desire for strict monitoring of materials reinjection (Pers. Comm., Barrow Whaling Captains Meetings, August 27 and 28, 1996:3).

Waste injection well design incorporates an understanding of confining zone stratigraphy to avoid potential cross-contamination of non-target formations. Waste injection zones are isolated from other formations by low permeability barriers or confining zones (Section 5.3.1.2). The proposed injection, arresting, and confining zones beneath the Northstar Unit (Figure 5.3-3) are within the same formations as those successfully utilized for waste disposal and confinement at the onshore Prudhoe Bay and Endicott units. Groundwater zones above the confining layer and below the permafrost are not considered to be potential drinking water sources due to their salinity (Sloan, 1987:241-243). During the drilling process, casing strings would be positioned and cemented to seal the non-target formations from potential impacts by Northstar reservoir fluids or waste injection fluids. Risks of fluid migration through the wellbore are expected to be slight because of the use of proven, reliable cementing practices consistent with all applicable regulatory requirements.

The maximum total volume of wastes to be injected, including drilling mud, cuttings, produced water, and domestic wastes, is estimated at 120 million barrels during the life of the project. Induced fracturing of injection zones is necessary for placement of these wastes. If the total volume were placed only into the lower injection zone (Figure 5.3-3), the estimated lateral area of influence would extend approximately

1,600 ft (489 m) from the wellbore. It is estimated that vertical fracture growth would be on the order of 250 ft (76 m), and not more than 500 ft (152 m). Even if induced vertical fractures extended past the maximum estimate, there would still be approximately 800 ft (244 m) of vertical section before reaching the top of the upper confining zone (Figure 5.3-3). Furthermore, permafrost is located between the uppermost confining layer and the seafloor, providing an additional barrier to the upward migration of wastes. To further reduce the risk of vertical migration of wastes through induced fractures, the upper injection zone would be used only if necessary, following initial use of the lower injection zone, and then would be used for low solids content wastes (such as domestic wastes) that do not propagate fractures as well as high solids wastes (such as drill cuttings). Consequently, overall impacts to the subsurface geologic environment and shallow sediment quality from injection of wastes are expected to be minor and confined to the injection zone.

Shallow gas accumulations have not been encountered during exploration drilling at Seal or Northstar Islands. In addition, to date there have been no indications of shallow gas accumulations or well control incidents in wells drilled on the North Slope. However, since scattered areas of shallow gas have been mapped on the inner continental shelf, it is considered to have a low risk of occurrence during drilling. Gas hydrates are estimated to occur beneath the Northstar Unit at depths ranging from approximately 2,953 to 4,921 ft (900 to 1,500 m) (Collett - Pers. Comm., 1997:2). Although pressurized gas and gas hydrates could pose a hazard to drilling activities, the use of standard well protection procedures, such as drilling muds, diverters, and blowout preventors, and closely monitored drilling rates that are currently in practice on the North Slope, would control the effect of gas accumulations or hydrates, if encountered. Consequently, the impact level is considered minor.

NPDES permitted discharges to the marine environment would occur during routine island operations and include system flushwater, brine from a desalination system, treated domestic/sanitary wastewater, and fire suppression test water. These discharges are further described in Chapter 4 and Appendix O. All but the fire system test water would be discharged via an outfall through the island's seawalls to the receiving seawater. This outfall requires a mixing zone to ensure compliance with the water quality standards of the State of Alaska. Discharges from this outfall may contact a small area of the island toe. Because of the small size of this mixing zone (16.4 ft [5 m] radius), the impact to sediments by these particular discharges is considered to be negligible. The fire system test involves discharging ambient seawater once a year for 30 minutes through the island's fire fighting system. This test will discharge onto the Beaufort Sea's surface; hence, no impact to sediments is expected.

Surface runoff on the island surface would be the product of snowmelt, rain, waves, and storms. Designs for Alternatives 2 through 5 include drainage control via two catchment basins. Contents of the catchment basins would be injected into the Class I industrial waste disposal well or transported to an approved onshore facility for disposal. As a result, no impacts to sediment quality from surface runoff is expected.

Ice-bonded permafrost is expected to occur beginning at a depth of approximately 300 ft (90 m) below the seafloor at the Seal Island location (BPXA, 1996b:Exhibit 3-2). In addition, a freeze front will progress down through the island following reconstruction. Local thaw settlements may result around the production wellbores and in areas of newly placed gravel as the island freezes and thaws. Thaw settlements up to 2 ft (0.6 m) have been observed in new gravel islands that are constructed in the winter (Tart, 1983:1236). Most of the settlement is expected during the first summer following construction, and subsequent settlement is expected to be relatively small. Design concerns from thaw subsidence at the island include settlement of surface facilities and the ground surface around production casings (Mitchell et al., 1983:855). These impacts are expected to be minor due to maintenance activities, including gravel replacement and annual regrading of the island's surface.

Thaw settlement analyses showed that areas of bonded subsea permafrost would develop a maximum thaw bulb of 35 ft (11 m) below the buried pipelines and 60 ft (18 m) on either side of the pipelines over a 20-year period (INTEC, 1998a:Appendix A). Thaw settlements of up to 2 ft (0.6 m) were predicted. These data (Miller, 1996:Plate.8; McClelland-EBA, 1985:Plate 26; INTEC, 1996a:Appendix A-Fig.26) are expected to be representative of the nearshore portions for Alternatives 2, 3, and 4. The maximum predicted settlement was used in calculations to design pipeline wall thicknesses and diameters capable of withstanding maximum strain (INTEC, 1997a:4). Thus, the impact of nearshore thaw settlement on pipeline stability is considered to be minor.

A local Nuiqsut elder expressed concern about the potential effects of permafrost on the pipeline shore approach (Pers. Comm., Nuiqsut Community Meetings, August 14, 1996:3-4). An evaluation of permafrost behavior in the area of the shore approach was conducted for Alternative 2 (and, therefore, Alternative 3) by INTEC Engineering, Inc. (INTEC, 1996a) based on onshore geotechnical data (Miller, 1996:Appendices A and B). Non-insulated pipes were predicted to develop a maximum thaw bulb that would extend to a depth of approximately 11 ft (3 m) below the pipe and to 7 ft (2 m) on either side of the pipe over a 5-year period. After 5 years of operation, thawing around the pipeline's shore approach was predicted to stabilize. Thaw settlements up to 2 ft (0.6 m) were predicted for soils under the nearshore section of pipeline in Simpson Lagoon (INTEC, 1996a:13). These data are also expected to be representative of the shore approach for Alternative 4 because of the similarity in coastal soil types between Point Storkersen and West Dock (Miller, 1996:Plates A41-A44 and A59-A60; Osterkamp and Harrison, 1976:Appendix A-Nos. 5 and 14). These data were used to design wall thickness and material requirements for the pipeline, and depth of the gravel-backfilled trench in the shoreline approach. Results of the analysis showed that a trench depth of 7 ft (2.1 m) would adequately protect the pipeline at the shoreline. Removal of the native soil and use of select backfill would also mitigate thaw bulb difficulties associated with the shoreline approach. Thus, pipeline design is expected to reduce the impact of permafrost thaw settlement at shoreline to a minor level.

Production of hydrocarbon fluids from the Northstar reservoir would result in removal of a substantial volume of oil resources that are not renewable on a human time scale. Effects on non-target, geologic formations or reservoirs as a result of drilling and oil production would be prevented through design features, such as the use of casing to seal off formations above the producing reservoir. The depletion of oil would have a negligible impact on the geologic environment.

The withdrawal of oil from geologic formations has caused measureable ground subsidence in a few oil fields around the world (for example, North Sea and Long Beach, California). Ground subsidence has not been experienced in the history of oil development on the North Slope. Reservoir pressures are expected to be maintained in the Northstar Unit through fluid or gas injection. For these reasons, and because the Northstar reservoir is relatively deep, the probability that subsidence would occur is considered to be very low. Consequently, the impact level is considered to be negligible.

Nuiqsut residents expressed concern at a community meeting that the pipeline could vibrate during operation, work its way out of the sediment, and float to the surface (Pers. Comm., Nuiqsut Community Meeting, August 14, 1997). However, the pipeline's specific gravity and method of installation with overlying sediments of sufficient density would prevent the pipeline from vibrating itself out of its trench (INTEC, 1997c:9-12). Consequently, the impact level is considered to be negligible.

The design of the onshore pipeline for Alternatives 2, 3, 4, and 5 would include features and construction methods used successfully in the Arctic for many years. VSMs would be designed to have minimal thermal effect on permafrost. Seasonal freeze-thaw cycles can create frost heave forces on the pile system (INTEC, 1996f:Appendix A). Heave calculations and soil type considerations would be incorporated into the design of minimum pile depths for the VSMs. The use of accepted VSM design criteria would result in negligible to minor impacts to permafrost.

To simplify construction and minimize effects to hydrological resources, onshore pipeline routes would avoid surface water features, such as ponds, lakes, and streams. The aboveground pipeline route river crossing planned at the Putuligayuk River is designed to protect the pipeline and minimize impact to the river. Flow in the Putuligayuk River peaks rapidly during breakup in early June, and falls gradually throughout the summer. Erosion would be possible during breakup when water levels are high and ice is present. The pipeline would be supported by VSMs over the length of the crossing. No disturbances of the river bank are anticipated as VSMs would be placed within the channel just downstream from the existing pipeline bridge. Naturally-occurring scour and bank erosion along the river would not be expected to affect the integrity of the VSMs in the river. VSMs would be installed at depths to resist ice impact at breakup. Hence, physical hydrologic processes should have no detrimental effects on the onshore pipeline.

An average coastal erosion rate of 2.6 ft/yr (0.8 m/yr) has been measured at the Alternatives 2 and 3 landfalls (Figure 5.3-7). For Alternative 4, average coastal erosion rates ranging from 1.3 to 9.8 ft/yr (0.4 to 3.0 m/yr) have been measured between Point McIntyre and the base of West Dock (Figure 5.3-7). A rate of 3 ft/yr (0.9 m/yr) was used in the preliminary design of the coastal set-back for the shore approach facilities (INTEC, 1997b:5). The pipeline is buried deep enough that erosion will not uncover it. In the event of a rare storm resulting in substantial erosion (e.g., a 30 ft [9.1 m] erosion event), the gravel material above the pipeline is sufficient to protect the pipeline from exposure or movement. The design setback distance from the pipeline shore crossing to the aboveground pipeline transition is approximately 110 ft (33.5 m). With an expected shore erosion rate of 3 ft/yr (0.9 m/yr) or less over the project's life of 15 years, this setback is sufficient to protect the pipeline. However, in the event of unexpectedly high rates of erosion due to a severe storm, the pipeline shoreline crossing would be monitored and inspected to determine the extent of erosion. Following such an event, some stablizing remedial action may be required, such as shoreline protection and nourishment (i.e., the replacement of eroded material). The coastal set-back distance, the buried pipeline depth, and gravel backfill are expected to reduce the impact of coastal erosion to a minor level.

Because the gravel causeway (West Dock) on which Alternative 5's subsea pipeline transitions to shore is regularly replenished with gravel lost to erosion, coastal erosion is not expected to affect pipeline integrity for Alternative 5.

Erosion of the coastline at the Alternative 2, 3, 4, and 5 shore approach could occur through both thermal degradation and longshore drift processes (Section 5.3.1.6), causing select gravel backfill used in the shore approach to be exposed. Based on the historic rate of erosion at the Alternative 2 and 3 landfall, it is expected that approximately 40 ft (12 m) of coastline could be lost over the life of the project, potentially exposing the gravel backfill. A coastline retreat ranging anywhere from 20 to 150 ft (6 to 46 m) for Alternative 4 could occur over the life of the project, potentially exposing the gravel backfill. It is possible that the exposed gravel could alter natural sediment transport processes along the coastline. Because the gravel would be coarser than the beach or lagoon sediments, it is not expected to be transported far along the shoreline (less than a few hundred feet). The exposed gravel would resist erosion better than the surrounding sediments, potentially resulting in a small promontory. However, the area is relatively protected from longshore drift sediment transport by the barrier islands and West Dock, and the impact of this potential promontory on accelerating erosion or sediment buildup is expected to be minor.

Stump Island is known to be extending toward the west. Based on the rate of extension measured from aerial photographs since 1955 (Figure 5.3-8), the island is expected to extend to the west approximately 0.1 mile (0.16 km) over the life of the project. It is very unlikely that the island would reach the Alternative 2 and 3 pipeline route (0.2 miles [0.3 km] further west) during the life of the project. No impacts to Alternative 4 and 5 pipeline routes, on the north and east sides of Stump Island, are expected to occur due to island extension. If it were to reach the pipeline, it would result in the beneficial effect of an increase in sediment thickness covering the pipeline. The impact of barrier island migration to the pipeline is considered to be negligible.

Storm surges also could have an impact on Alternatives 2, 3, 4, and 5 pipeline routes in the vicinity of the barrier islands. The nearshore pipeline segments of Alternatives 4 and 5 paralleling the north side of Stump Island would be more susceptible to high energy marine forces than either the lagoon or offshore segments. The Alternative 5 offshore pipeline route could also experience sediment erosion effects from currents passing through the West Dock Breach located about 500 ft (150 m) offshore of the Dock 2 approach. The breach is approximately 650 ft (200 m) wide and was designed to maintain a minimum water depth of 6 ft (2 m) below mean lower low water (MLLW). Breach supports were designed to withstand scour depths of up to 40 ft (12 m). Three years of bathymetric surveys in the area indicate that maximum water depths resulting from scour have ranged from approximately -8.5 to -9.5 ft (-2.6 to -2.9 m) MLLW in an area within approximately 150 ft (46 m) on either side of the breach (ARCO, 1997:Sheet 1; CFC, 1995:Sheet 1; CFC, 1996:Sheet 1). These data suggest that scour depths exceeding about 4 ft (1.2 m) below the seafloor, or -10 ft (-3.3 m) MLLW, would be the maximum depth of erosion in this area. Scour depths of this nature are considered to be of minor impact to pipeline integrity.

Marine water escaping the lagoonal area following a storm surge could cause channeling or breaches to occur where none currently exist. Sediment covering the pipeline could erode during such an event. The depth of pipeline installation in the vicinity of the barrier islands (6 ft [1.8 m]) is equivalent to the deepest existing channel between islands in the area, minimizing the risk to pipeline integrity in the event of storm surge and sediment erosion (INTEC, 1996b:8). Consequently, the impact to pipeline integrity is considered to be minor.

It is anticipated that an oil spill would have some effect on geological resources and onshore hydrological features. Impacts to soils, onshore water bodies, and seafloor sediments are discussed in Chapter 8.

Maintenance Impacts: Inspection of onshore pipelines and VSMs would be conducted along existing roads or, for locations remote from a road, via helicopter. Disturbance to onshore soils in the event of a major pipeline or shore approach repair would occur over a short duration (e.g., a single several month-long season) and would be limited to localized areas adjacent to the repair (e.g., several acres). Major repairs would occur in the winter, except for emergencies. Winter repairs would be accessed via ice roads built specifically for that purpose, and are expected to have a negligible impact on soils. Impacts to soils during a summer repair would be greater than that for a winter repair, but would be expected to result in a minor impact on soil due to special equipment that would be used to access the damaged section. Access for a summer repair would be via helicopter or all-terrain vehicles, which may result in compaction, but not removal, of vegetation. Consequently, overall impacts to soils from routine maintenance and repair activities along the onshore segment of the pipeline would be negligible to minor.

Regular pipeline inspections and pigging would be conducted to detect possible damage to the buried offshore pipeline segment due to thaw settlement or heave. Inspections would include monitoring pipeline geometry and visual or marine survey inspections and would be conducted at start-up, then annually for the first 5 years, and every 2 years thereafter (INTEC, 1996c:5-6; HLA, 1997:2). Offshore pipeline repair becomes more complex with increasing water depth. If repairs to the offshore pipeline are required, sediment would be disturbed locally. Typical offshore repair scenarios range from 25 to 50 days and require sediment excavations ranging from 900 to 16,000 yd^3 (688 to 12,233 m^3) (INTEC, 1996c:Table A.2). In summer, operations would be carried out from a barge or barges. In winter, repair activities would be carried out from the surface of the ice utilizing techniques and equipment similar to those employed during the construction phase. Spoils would be temporarily stored on ice or a barge, and would be backfilled into the trench. These disturbances would be over a short duration (within a single season) and would have minor impact to offshore sediment.

Pipeline and VSM integrity and river bank and channel integrity would be monitored at the Putuligayuk River crossing. Should natural scour or erosion processes threaten the structure of the bank or the pipeline, repairs would be affected. Typically, bank erosion has been repaired with grout bags, which protect the bank from ice and/or water scour (INTEC, 1996d:B-7). Impacts from repairs of this nature are minor.

The gravel island is expected to subside during the first few years following construction due to thawing of permafrost and compaction of underlying sediment. In addition, the island slopes may be damaged by ice or oceanographic processes each year, potentially causing sedimentation impacts to the seafloor. Planned yearly maintenance, as well as the use of filter fabric and concrete armoring in the slope design, would minimize sedimentation impacts to the seafloor. Annual maintenance and repair of the island would include regrading the island work surface following spring breakup, grading prior to freezeup, and replenishment by backpassing or dumping of the gravel berm as necessary. Impacts to seafloor sediment from maintenance activities would be negligible to minor.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving onshore pipeline removal, impacts would likely be minor if abandonment were performed during winter. Removal of the offshore pipeline would be conducted in a similar manner to the installation, and would involve winter trenching through sea ice. The trench would be backfilled with spoils following pipeline removal. The impact on sediment would be similar to the impact of offshore pipeline construction discussed previously, that is, negligible to minor.

In place abandonment of the onshore and offshore pipelines would have no immediate physical impact to soils or seafloor sediment and have less impact than the physical removal of the pipeline. However, damage to the onshore pipeline could occur over time, and erosion of sediment could result in the offshore pipeline being uncovered. Since all oil would be removed from the pipeline as part of this abandonment scenario, impacts to soils and sediment from post-abandonment damage would be negligible to minor.

In the case of island abandonment, the island would be allowed to erode by natural processes, resulting in the introduction of gravel into the marine environment. The impact on sediment would be negligible to minor. Preservation of the island would have no impact on sediment.

5.3.3 Summary

No unavoidable adverse effects, or impacts, were identified for onshore and offshore geological and onshore hydrological resources as a result of implementing the project. This includes any direct and indirect impacts due to construction activities, operational characteristics (with the exception of an oil spill), maintenance procedures and abandonment options.

The primary issues or concerns, related to resources within the physical environment were the potential for direct and long-term impacts to soils, permafrost, and sediment quality, and from accelerated coastal erosion and hazards to project facilities from natural phenomenon. Overall, negligible to minor impacts are anticipated for these resources.

Resources committed to the project would be material and nonmaterial. The project would require an irreversible commitment of geologic resources, i.e., oil and gas reserves. Ground disturbance associated with installation of the subsea pipeline, the onshore VSMs, and gravel mining for reconstruction of the island and associated onshore facilities are also irreversible, as are the direct effect to soils and permafrost during the life of the project.

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- Ahkiviana, Archie

5.4 METEOROLOGY AND AIR QUALITY

5.4.1 Affected Environment

This section discusses aspects of the affected environment related to meteorology and air quality. Meteorological information for the project area is presented in Section 5.4.1.1. Air quality legislation and standards regulated by state and federal law are presented in Section 5.4.1.2. Section 5.4.1.3 describes the existing air quality of the project area.

5.4.1.1 Meteorology

Meteorological data (temperature, wind direction, wind speed, and precipitation) are collected hourly at the Deadhorse Airport located adjacent to the Prudhoe Bay Industrial Complex and at Barrow, 200 miles (322 km) west of the project area. Hourly data were also previously collected at the Barter Island weather station located 120 miles (193 km) to the east. Monthly averages at these stations are summarized in Table 5.4-1.

Climate: The project area is located in the Alaskan Arctic coastal (polar) climatic region and is characterized by persistent wind, low temperatures, and low precipitation. The summer season is short as a result of the high latitude (with continuous daylight) and winter is long (with 2 months of near continuous darkness). Snow covers the ground approximately 8 months of the year.

The National Weather Service operates a weather station in Barrow (Station 50-0546) and did operate another at Barter Island (Station 50-0558). Deadhorse Airport records maximum and minimum daily temperatures, and collects temperature, wind speed, and wind direction data hourly for the North Slope oil fields.

Temperature: Daily and seasonal temperatures are moderated by the maritime effect of the Arctic Ocean. The average annual temperature is 11°F (-12°C); however, temperatures range from -59°F (-51°C), with additional cold from windchill, to an average high of 70°F (21°C) (Gamara and Nunes, 1976:2). Equivalent windchill temperatures of -100°F (-73°C) have been recorded (Gamara and Nunes, 1976:3). Below freezing temperatures are experienced more than 80% of the year and have been recorded during every calendar month.

Elders have said that, in summer, a warm breeze and warming temperatures are indicators of an impending major storm (S. Kunaknana - Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). It was also stated that climate changes have resulted in warmer temperatures in recent years (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:4).

Wind: Lack of natural wind barriers in the Alaskan Arctic coastal zone results in unrestricted winds at an annual average of 13.3 miles per hour (21.3 km per hour). Whaling camp locations are partly chosen for wind protection. Whaling activities at other islands have been abandoned in favor of Cross Island, where more protection is available (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:27).

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East northeasterly winds prevail during summer months, and west southwesterly winds prevail between January and April (GRI, 1992:7; USDOI, NOAA and Ruffner, 1985:28). Gusting winds are highest and most frequent between September and November. Storms generally move into the area from the west. Nuiqsut whaling captains explained that Seal Island is most vulnerable in a southwest wind, compared to milder effects of a northeast wind (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). Southwest winds have interfered with whaling, forcing hunters to abandon whales (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). A Barrow whaling captain reported that the prevailing wind is northeast in fall and winter, with occasional strong west winds.

Precipitation: Drizzling rain accounts for most of the precipitation along the Alaskan Beaufort Sea. Relative humidity in summer along the coast ranges from 80% to 95%. The relative humidity in winter drops to about 60%, resulting in very light density, granular snowfall. The light, granular snow and persistent wind may create inaccurate snowfall measurements due to drifting and blowing snow (USDOI, FWS, 1987:10). Average annual precipitation ranges from 4.8 inches (12.2 centimeters [cm]) at Barrow to 6.5 inches (17 cm) at Barter Island and occurs mostly as rain in summer. Annual average precipitation recorded at Prudhoe Bay from 1983 to 1993 indicate 7 inches (17.8 cm) of rain/snow fall. Records kept by the National Weather Service indicate a maximum 24-hour rainfall event of 1.32 inches (3.35 cm) over a 72-year recording period (Pollard - Pers. Comm., 1998:1). Data for Oliktok Point and Barter Island indicate 24-hour maximum events of 3.00 and 2.25 inches (7.62 and 5.72 cm), respectively (Brower et al., 1977:22). October has the highest average snowfall and June the lowest, but records show that snow has fallen in every calendar month. Blizzards and whiteouts occur frequently in winter due to the combination of light granular snow and periods of high winds.

Snowfall generally begins during the last part of September or early October and fog and ice form during this period (W. Matumiak in USDOI, MMS, 1990a:41). Nuiqsut hunters indicate that snow drifting around Seal Island begins in October, explaining that October through December are the critical months for snow drifts (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996).

Inupiat residents have relayed numerous accounts of their experience with extreme storms. Weather is described as constantly changing and unpredictable, with the largest storms occurring in September. With little warning, sudden and extreme storms can occur in the Alaskan Beaufort Sea (J. Ningeak in USDOI, MMS, 1990b:20-21). Storms can come from different directions, but usually are from the north, and the area inside the barrier islands is not heavily impacted by storms (S. Kunaknana - Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

5.4.1.2 Air Quality Legislation and Standards

Air quality is influenced by the interaction of air pollution with climatic conditions. Poor air quality can result in harmful effects to human health, animals, and vegetation, and can damage buildings and other objects. The Clean Air Act (CAA) was passed by Congress in 1963 to establish air quality standards. The CAA of 1970 and CAA Amendments of 1990 are the principal air quality laws in the United States. The State of Alaska Air Quality regulations are published in the Alaska Administrative Code (AAC), Chapter 50 of Title 18 (18 AAC 50), effective January 18, 1997. Pertinent sections of this legislation and regulations are summarized below.

U.S. Environmental Protection Agency (EPA) Regulations: EPA regulations regarding air quality that are applicable to this project are discussed below.

National Ambient Air Quality Standards (NAAQS): Primary and secondary NAAQS were established for six criteria pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter (PM), oxides of nitrogen (NO_x), ozone (O_3), and lead (Table 5.4-2). Primary standards are designed to protect human health, and secondary standards protect crops, vegetation, forests, and animals. Criteria pollutants are mainly waste products from burning fossil fuels.

In July 1997, the EPA promulgated new ambient air quality standards for ozone (8-hour averaging period) and particulate matter with an aerodynamic diameter of less than 2.5 microns (24-hour and annual average). These standards are being phased into existence, and they are not quantitatively addressed in this document.

Prevention of Significant Deterioration (PSD): The EPA has promulgated regulations to prevent further significant deterioration of the air quality in areas where the ambient air quality is better than the NAAQS.

The PSD Regulations (40 FR 52.21) define a "major stationary source" as any source type belonging to a list of 28 source categories that emits or has the potential to emit 100 tons per year (tpy) or more of any pollutant regulated under the CAA, or any other source type that emits or has the potential to emit pollutants in amounts equal to or greater than 250 tpy [40 CFR 52.21(b)(1)(I)]. The potential to emit is based on the maximum design capacity of a source, subject to federally enforceable permit limitations (e.g., limits on annual hours of operation) and takes into account pollution control efficiency [40 CFR 51.166(b)(4)].

Oil and gas development/production activities associated with the Northstar project are not included in the 28 listed source category types; thus, the 250 tpy threshold criterion for PSD sources is applicable. If the emission level of any one pollutant exceeds 250 tpy, it creates a major source, then a PSD review is applicable to other pollutants emitted in amounts as defined in 40 CFR 52.21 (b)(23)(I) (Table 5.4-3).

The proposed emission rates for the Northstar unit development/production show that the facility will be a major stationary source and, therefore, PSD review must be conducted for each pollutant with potential emissions equal to or greater than their respective PSD significant emission levels. The proposed project emissions trigger a PSD review for NO_X, CO, O_3 (precursor to volatile organic compounds), SO_2, and PM_{10}.

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The following classifications are defined by the EPA:

· Class I: Near pristine air; no significant new pollution source would be allowed. These areas are generally national parks, wilderness areas, and monuments.

· Class II: Moderate deterioration of air would be allowed within the limits of PSD increments. Most of the U.S. falls into this classification.

· Class III: Deterioration of air would be allowed up to the NAAQS limit.

The project area is designated PSD Class II. The nearest Class I area, Denali National Park, is 400 miles (644 km) to the south. PSD Class I and Class II increments are shown in Table 5.4-4. Only the Class II increments are applicable to the project area. Ambient, or surrounding, air quality is regulated by the Alaska Department of Environmental Conservation (ADEC) and the EPA. ADEC has PSD authority and implements monitoring and enforcement of regulations established under the federal programs described above.

Major provisions of the PSD review would include the following analyses:

Analysis of Best Available Control Technology (BACT).
Source Impact Analysis for demonstration of compliance with NAAQS.
Source Impact Analysis for demonstration of compliance with PSD Class II Increments.

<u>New Source Performance Standards</u>: The Federal New Source Performance Standards are applicable to specific categories of sources and apply to new sources of air pollution as well as to modified or reconstructed existing sources (40 CFR 60, Standards of Performance for New Stationary Sources). The standards apply to facilities with stationary combustion sources. An affected source means "any apparatus of the type for which a standard is promulgated ... and the construction or modification of which was commenced before the date of proposal of that standard...". The following subparts apply to development/production of the Northstar Unit.

· Subpart Kb, *"Standards of Performance for Volatile Organic Liquid Storage Vessels (Including Petroleum Liquid Storage Vessels) for Which Construction, Reconstruction, or Modification Commenced after July 23, 1984."* This standard applies to the diesel storage tank to be located at the Northstar facility. This tank exceeds the threshold size of 10,560 gallons (39,970 liters). Because of the low vapor pressure of diesel, however, the only requirement that must be satisfied for this tank will be to maintain records of the size and capacity of the tank.

· Subpart GG, *"Standards of Performance for Stationary Gas Turbines."* This standard is applicable to all stationary gas turbines with a heat input at peak load equal to or greater than 10.7×10^9 joules per hour (10.1 million British thermal units per hour [Btu/hr]) based on the lower heating value of the fuel fired. The equipment inventory for development/production of the Northstar Unit indicates there are

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turbines which have heat capacities greater than 10.1 million Btu/hr. These turbines must meet the requirements of Subpart GG.

· Subpart Dc, *"Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units."* This standard is applicable to steam generating units with a heat input of greater than 10 million Btu/hr, but less than 100 million Btu/hr. The waste heat recovery unit for the Northstar Unit falls within this heat input range. This unit must meet the requirements of Subpart Dc.

<u>National Emission Standards for Hazardous Air Pollutants</u>: Section 112 of the CAA, as amended, required the EPA to publish a list of hazardous air pollutants for which National Emission Standards for Hazardous Air Pollutants would be developed. These standards were promulgated for specific industries and pollutants according to 40 CFR 61 (i.e., asbestos, beryllium, mercury, radon, radionuclides, vinyl chloride, benzene, and inorganic arsenic). Although these standards are promulgated on a source-specific basis, none of them apply to Northstar Unit development/production activities.

State of Alaska Air Quality Regulations: These regulations apply to any person who allows or causes air contaminants to be emitted into ambient air. The Alaska ambient air quality standards are identical to the NAAQS (Table 5.4-2), but also include a reduced sulfur compound standard and an ammonia standard. For reduced sulfur compounds, expressed as SO_2, a 30-minute average of 50 micrograms per cubic meter may not be exceeded more than once a year; and for ammonia, 2.1 milligrams per cubic meter, averaged over a consecutive 8-hour period, may not be exceeded more than once per year.

State of Alaska regulations applicable to development/production of the Northstar Unit are presented in Appendix D.

Permit Requirements: Based on the above state and federal requirements, the project will require a State of Alaska PSD permit for construction, drilling, and operation. A separate Title V operating permit will be issued after issuance of the PSD permit.

5.4.1.3 Existing Ambient Air Quality

Existing air quality for the onshore project area has concentrations of criteria air pollutants generally far less than the NAAQS and state standards (USDOI, MMS, 1996:IIIA-14). Onshore emission sources in the region include small diesel-electric generators at the villages of Barrow, Nuiqsut, and Kaktovik and major industrial sources at the Prudhoe Bay, Kuparuk, Endicott, Milne Point, and Lisburne oil production facilities.

Various monitoring programs conducted show that compliance with ambient air quality standards generally is maintained in the region, even at sites expected to have the highest concentrations of pollutants. Four sites were selected for air monitoring conducted in 1986 and 1987. Two sites were to be representative of maximum pollutant concentrations in the industrial area (Prudhoe Bay facilities), and two sites were to be representative of general air quality (isolated from industrial sources) in the area (Kuparuk facilities). An additional monitoring site was selected for the Prudhoe Bay area at Gathering

Center 1. All ambient air quality criteria pollutants except lead were monitored at these sites. Data collected from these sites from 1990 through 1996 are summarized in Table 5.4-5. All values measured at these sites meet the current (1997) state and federal ambient air quality standards, except one exceedance of the PM_{10} 24-hour standard. The PM_{10} 24-hour standard is not to be exceeded more than once per year.

Current allowable emission rates of onshore operating sources are summarized on Table 5.4-6. Actual emissions, as reported to the ADEC for 1994/1995 for all facilities in the western (BP Exploration (Alaska) Inc.-operated) and eastern (ARCO Alaska, Inc. [ARCO]-operated) operating areas, are summarized in Table 5.4-7.

Arctic haze, a phenomenon that affects air quality, occurs in winter and spring. Weather reconnaissance crews first reported Arctic haze in the 1950s, well before any development in the Arctic. Visibility was reportedly reduced from more than 50 miles (81 km) to less than 5 miles (8 km). Atmospheric chemists have collected data at Barrow and Narwhal Island, as well as other sites that experience Arctic haze in Scandinavia, Norway, and Greenland. The data show high concentrations of sulfate and vanadium at Barrow. Vanadium is a pollutant resulting from the burning of heavy industrial oils, commonly used as fuel. Chemists believe the haze is a result of long-range transport of pollution from industrialized Europe (Kerr, 1979:290-293).

North Slope residents have commented on Arctic haze in the past, including the public hearing on Lease Sale 144 and during scoping meetings and public hearings for this EIS (Section 7.8.1.2). They describe this haze as a smog and yellow smog that is visible during cold weather (F. Long, Jr. and J. Akpik, USDOI, MMS, 1995:23 and 32, respectively).

Offshore air quality within the Northstar Unit is expected to be near global background levels due to its location. The Northstar Unit is isolated from major pollutant emission sources other than the existing onshore production facilities described previously.

5.4.2 Environmental Consequences

The following section describes potential impacts of each project alternative on air quality. The discussion of impacts is organized according to project alternatives described in Section 4.4. Discussion of Alternative 1 - No Action Alternative is presented first, followed by the remaining alternatives. Alternatives 2, 3, 4, and 5 are very similar with respect to air quality and are therefore discussed together. Impacts are summarized in Table 5.4-8.

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5.4.2.1 Alternative 1 - No Action Alternative

Implementation of the No Action Alternative would not cause any changes to the existing meteorological conditions or ambient air quality. With the No Action Alternative, existing operations associated with onshore oil and gas activities would continue, decreasing with the decline in oil production. Air quality effects as a result of emissions from current operations would likely improve over the long term. However, the degree to which air quality may improve is uncertain.

5.4.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Construction-related activities include utilization of various heavy duty diesel-fired equipment (both mobile and stationary source) for onshore and offshore portions of the project. Activities include ice road construction, operation of a gravel mine, operation of a concrete block plant and a screening plant, reconstruction of Seal Island, construction of onshore and offshore pipelines, and on-island construction.

Various ice roads for trucks hauling gravel to rebuild Seal Island would be constructed between the mine site and Seal Island for trucks traveling between the West Dock causeway and the gravel mine site, and for the onshore pipeline route. Emissions from equipment used for ice road construction would be mostly mobile source, temporary and localized, and the impact on air quality would be minor. These activities would not require an air permit or dispersion modeling.

A new gravel mine near the mouth of the Kuparuk River would be used as a gravel source for reconstruction of Seal Island. Potential for dust emissions from gravel mining is low because much of the blasted extracted gravel will be partially frozen or ice-bound, limiting liberation of dust particles from soils. Fuel consumed by mobile equipment (front-end loaders, dump trucks, and graders) would contribute to localized pollution. Air quality impacts from gravel mining activities would be minor (as determined in part by dispersion modeling). These gravel mine activities have been evaluated and are below major source threshold limits; therefore, no air permit or additional dispersion modeling is required (RILLC, 1996:ES-1).

The operation of a concrete block plant and a screening plant would involve mobile and stationary sources of criteria pollutants. The impacts from these plants would be temporary and localized, and the impact on air quality would be minor. These activities would not require an air permit or dispersion modeling.

Mobile sources such as a ditch witch (backhoe with a cutting blade), a backhoe, and front-end loaders would be used for reconstruction of Seal Island to dump and level gravel. The potential for dust emissions is low; however, increased emissions would occur from heavy equipment operation. Island construction activities would be temporary and localized, and the impact on air quality would be minor. These activities would not require an air permit or dispersion modeling.

Construction of onshore and offshore pipelines would involve mobile and stationary sources of air pollutants. Heavy duty diesel-fired equipment would emit criteria pollutants. Onshore pipeline installation would require a small drilling unit to drill piling holes for VSMs. Onshore pipeline construction for Alternatives 2, 3, 4, and 5 would also require the following bus/truck trips: 900/820, 1,125/1,025, 837/762, and 957/7,691, respectively. Offshore pipeline construction for Alternatives 2 and 3 would require 650 bus and 254 truck trips. For Alternatives 4 and 5, the number of bus/truck trips required would be 985/384 and 969/379, respectively. These impacts would be temporary and localized, and the impact on air quality would be minor (as determined in part by dispersion modeling). These activities would not require an air permit.

On-island construction activities would involve civil activities, non-civil activities, and the ongoing use of a reserve pool of construction equipment. The civil activities include foundation installation, slope armor installation, and pipeline tie ins; all other activities are non-civil, and include electrical, piping, mechanical, and other construction activities. Reserve pool equipment activities would primarily include the use of diesel-fired internal combustion engines and heaters. The annual air emissions of criteria pollutants for these activities are presented in Table 5.4-9. A PSD permit application, submitted to ADEC in February 1998, addresses the impacts of these on-island construction activities. There is minimal overlap between these construction activities and drilling/production operation activities. Air quality dispersion modeling impacts for these activities are presented in Table 5.4-10. These results show compliance with the NAAQS, and impacts are minor. Major sources of nitrogen dioxide (NO_2) emissions (Table 5.4-6) were included as background in this modeling analysis. Lisburne and the Deadhorse Power Plant air emission rates were included in the analysis because of their size and proximity. Milne Point, Badami, and Pump Station No. 1 were not included in the analysis, primarily due to size of emissions and distance from the Northstar project. The allowable emission rates are permitted emission rates (rather than actual emission rates). Thus, the modeling analysis should be conservative. Short-term and long-term emission rates resulting from air dispersion modeling analyses are provided in Table 5.4-6. Emissions of PM_{10}, CO, and SO_2 from background sources would not affect the model results and they were not included in the analysis.

Drilling and Operation Impacts: Drilling and operation activities would be subject to federal air quality permitting regulations, including New Source Performance Standards and National Emissions Standards for Hazardous Air Pollutants. In February 1998, a PSD permit application was submitted to ADEC to address drilling and operations impacts (this application was amended in August 1998). Drilling and operations equipment would have to meet BACT requirements for low emission combustion technology, fuel injection timing retardation, and catalytic oxidation. Methodology used to identify BACT is the five step “top-down” methodology recommended by the EPA. In addition, operation activities would be in accordance with the manufacturer design, which also constitutes compliance with BACT.

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Proposed BACT controls have been described in the PSD air quality permit application for drilling and operation activities. These controls apply to all pollutants and source types and are based on technical feasibility and economic, environmental, and energy impacts. The proposed BACT controls for drilling and operation activities are summarized in Table 5.4-11.

The proposed annual air emissions inventory for the long-term drilling and operation activities are shown in Table 5.4-12. This inventory assumes electric power would be supplied to the drilling rig from the Mars gas turbines. Drilling rig equipment, including heaters and boilers, are also shown in Table 5.4-12. The portable equipment includes a crane, light plants, snowblowers, a welding unit, and portable heaters and engines.

The ambient air quality impacts of drilling and operation activities compared to the NAAQS are shown in Table 5.4-13. Major sources of NO_2 emissions (Table 5.4-6) were included in the modeling as background. The emissions of PM_{10}, CO, and SO_2 from background sources would not affect the model results, thus they were not included in this analysis. Impacts for all pollutants are higher than those predicted for the drilling rig when firing natural gas, so this case has not been presented. These impacts also consider 720 hours per year (and 24 hours/day) of flaring activities from the gas flare. Essentially, this drilling/operation impact analysis presents a worst-case scenario for long-term project operations. Impacts for all pollutants are well below the NAAQS; therefore, air quality impacts from drilling and operation activities are minor.

The ambient air quality impacts of the drilling and operation activities compared to the PSD Class II increments for SO_2, PM_{10}, and NO_2 are below the applicable PSD Class II increments (Table 5.4-14). These impacts reflect BP Exploration (Alaska) Inc.'s proposed project and other increment-consuming services in the project area. These impacts also consider 720 hours per year (and 24 hours/day) of flaring activities from the gas flare. These impacts are expected to be minor. The ambient air quality impacts of the drilling and operation activities to the Arctic National Wildlife Refuge, Kaktovik, and Nuiqsut areas are well below the PSD Class II increments (Table 5.4-15). Impacts of drilling and operation activities are expected to be minor to these areas.

There will be some offshore flaring activities during the operation phase. The oil production facilities will occasionally experience emergency upset conditions that result in flaring of produced gas. These conditions result in emissions that are unplanned and are not subject to permitting requirements. It is expected that flaring occurrences will not exceed 30 days per year. This flare would be engineered to minimize incomplete combustion of gases, thus minimizing “speckling” of snow in the immediate vicinity of the flare. Impacts are expected to be minor.

A visibility impacts analysis was conducted for the Arctic National Wildlife Refuge area, and the results indicated that none of the Class I area criteria were exceeded. During drilling and operation activities, there will be air emission sources at onshore process facilities. These sources include:

- Shore Crossing - a thermoelectric generator (internal combustion engine).

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· CCP Tie-in Location - gas pipeline booster compressor (gas turbine) and a generator (internal combustion engine).

· Pump Station No. 1 - an indirect-fired crude oil heater and a space heater.

An air emission inventory for these three locations is shown in Table 5.4-16. It is currently estimated that the emissions from these sources would not trigger the need for an air quality permit to construct from ADEC. The CCP tie-in and Pump Station No. 1 would require an operations permit. Dispersion modeling of all these locations shows impacts would be minor.

The Northstar Unit process design would incorporate measures to reduce the emissions of greenhouse gases, specifically carbon-dioxide. Measures considered include selection of efficient turbine drivers, minimizing flaring during operational upsets, waste heat recovery techniques, and fuel gas pretreatment to reduce carbon-dioxide content.

Impacts as a result of oil spills and associated clean-up activities are anticipated and are discussed in Chapter 8.

Maintenance Impacts: Maintenance activities associated with operation of the production island and pipeline would take place year-round over the expected 15-year life of the project.

Maintenance and repairs of the island slope protection system would include replacement of concrete mat blocks. Operation of a concrete block plant at a gravel source location (likely to be the Putuligayuk River site) would be necessary if no surplus blocks were available from initial construction. The concrete block plant would operate only if necessary to manufacture new or additional island slope protection blocks. The operation of the concrete plant would result in a temporary, localized, and minor impact to air quality. Island surface maintenance and repairs also would be carried out seasonally. Activity at the island would involve the use of a crane working from the island surface and a work crew. Emissions from these onshore and offshore activities would have a negligible impact to air quality. Maintenance and repair of the gravel berm surrounding the island would result in temporary negligible impacts to air quality from fugitive dust associated with gravel mining, hauling, and placement, as well as vehicle emissions.

Pipeline inspections would include helicopter overflights and regular pigging operations between Seal Island and onshore facilities. Approximately 60 bus and 84 helicopter trips would be required for onshore pipeline maintenance over the 15-year life of the project. These activities would result in negligible impacts to air quality. Maintenance of the offshore pipeline could include excavation of the pipeline trench to make repairs. Trenching and repair of the pipeline would require use of heavy equipment, welding machines, light plants, and air compressors. Trucks and/or supply barges would be used for delivery of repair supplies and/or work crews. Air quality impacts associated with offshore pipeline repairs would be temporary, localized, and negligible.

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Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts would be expected to be similar to those generated during construction, and the overall impact to air quality as a result of abandonment would be expected to be negligible.

5.4.3 Summary of Environmental Consequences

No significant unavoidable adverse impacts to air quality from the project were identified. Short-term impacts include localized emissions from construction activities and are negligible to minor. Long-term impacts include emissions from facility operations and vehicles delivering supplies to the offshore site. These impacts to air quality are negligible to minor and will occur as a result of routine facility operation.

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- Napageak, Thomas

5.5 PHYSICAL OCEANOGRAPHY AND MARINE WATER QUALITY

5.5.1 Affected Environment

Oceanographic topics which affect the project include: the bathymetry of the project area, the effect of the region's weather on the surface of the sea, and local and regional currents which influence water movement beneath the surface of the sea. Marine water quality deals with the physical and chemical characteristics of seawater which may be affected by the project. Physical parameters include temperature, turbidity, suspended sediments, and density. Salinity, dissolved oxygen, nutrients, pH, trace metals, and naturally-occurring hydrocarbons are characterized by chemical parameters which may be used to assess project impacts to the nearshore environment.

An understanding of the oceanographic processes and baseline water quality in the project area allows for meaningful comparisons between project alternatives. Information presented in this section also is used to support the draft and preliminary final NPDES Permit (Appendices F and O) and its associated Fact Sheet (Appendix G), the Ocean Discharge Criteria Evaluation (Appendix H) and Section 103 Evaluation (Appendix I) documents for this project. These four documents address the release of water discharges and trenching spoils back into the Alaskan Beaufort Sea.

5.5.1.1 Bathymetry

Between the mainland and Stump Island, water depths are 0-5 ft (0-1.5 m). Between Stump Island and Seal Island, water depths are 0-40 ft (0-12 m). The appearance of the seafloor in the project area is a result of tides, currents, and other oceanographic processes. Sea ice processes such as gouging and strudel scour, also affect the appearance of the seafloor. (Leidersdorf and Gadd, 1996). North of Seal Island, the seafloor gently slopes downward in an offshore direction (Selkregg, 1975:41) toward the edge of the Alaskan Beaufort Sea continental shelf, approximately 60 miles (97 km) north of the project area. Beyond 60 miles (92 km), the seafloor drops off steeply into the Canada Basin of the Arctic Ocean.

The breach in the West Dock causeway (Figure 5.5-1) was constructed in 1994 to improve nearshore seawater circulation. The breach is 650 ft (198 m) long and spanned by a bridge. It was anticipated that the breach would alter bathymetry in the immediate vicinity of the causeway by constricting current flow and increasing current velocity. As a result, design specifications stipulated bridge support piles of sufficient length to withstand effects of seafloor scour to a depth of -40 ft (-12 m) MLLW.

5.5.1.2 Weather and Water Levels

Water level variations caused by wind generated waves, storm surges and, to a lesser extent, tides are important factors influencing nearshore oceanographic conditions in the project area.

Storm surges are changes in water level resulting from weather disturbances. They are most likely to occur from August through October, during the open water season, which also coincides with highest mean monthly wind speeds (Joy et al., 1979:4). The height of a storm surge is affected by atmospheric pressure; wind speed, direction, and duration; Coriolis effect; rainfall; and direction and speed of storm movement. Fetch, the length of open water surface across which the wind can blow, is a factor which determines wave height and the potential intensity of a storm surge. In some years, the pack ice is well north of the coast, resulting in a long fetch for westerly to northwesterly winds and the potential for high storm surges in the project area. Surge height is enhanced by a shallow, gently sloping seafloor similar to the seafloor at the project area.

Storm surges cause much larger variations in sea level than do astronomical tides (Gantz et al., 1982:35), whereas the tidal range in the project area is less than 12 inches (31 cm) (Figure 5.5-2) (WCC, 1997:2-1). Positive storm surges of 3 ft (0.9 m) above sea level are common along the Alaskan Beaufort Sea coast. Occasionally, larger storm surges of 3.3 to 6.5 ft (1 to 2 m) above sea level can occur (WCC, 1997:2-1). Nuiqsut whaling captains have observed that these large storm surges occur with southwesterly winds, not during northeast winds. (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:7). In the project area, barrier islands, artificial islands, and coastal facilities up to 0.6 miles (1 km) inland may be flooded during exceptional storms caused by westerly winds (Grantz et al., 1982:35). A Nuiqsut whaling captain described how storm surges overtop sea ice and come ashore up river drainages (F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8).

Rise or fall in water level from a storm surge is greatest along coastal areas where water depths become more shallow. In deeper offshore portions of the project area, such as at Seal Island, it is expected that the effect of storm surges would be much less. Positive storm surge estimates for Seal Island under westerly wind conditions indicate a maximum 1.1-ft (0.34 m) above sea level surge annually and a maximum 4.1-ft (1.2 m) above sea level surge based on a 100-year return period (OCTI, 1996, as cited in INTEC 1996:3-39).

In addition to storm surges, waves are an important oceanographic component which may affect project facilities. Wave height and period (frequency) are determined by wind velocity, duration, fetch, and water depth. Wave heights increase the longer the wind blows. In the project area, wind events usually last 2 to 3 days during the open water period. Based on studies performed on the shore at Point Storkersen, the largest waves had heights of 5 ft (1.5 m) and a period of approximately 6 seconds. The 100-year, westerly storm-

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Figure 5.5-2 (page 1 of 2)

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generated wave at Point Storkersen is predicted to be 4.4 ft (1.3 m) in height with a period of 4.8 seconds. Predicted wave heights and frequencies are listed in Table 5.5-1 for the shore at Point Storkersen (INTEC, 1996:3-39; Britch et al., 1983:219). Offshore of the barrier islands in the vicinity of Seal Island, waves are larger, due mainly to water depths and longer fetches, relative to the shallow, protected lagoon areas. Extreme wave predictions for Seal Island from the Beaufort Sea Hindcast model (based on 25 years of weather data) data are presented in Table 5.5-2.

5.5.1.3 Currents and Circulation

Nearshore currents along the coast in the project area are primarily wind driven during the open water season (Wilson, 1974:55-57). Currents usually orient along bathymetric contours that parallel the coast in an east-west direction (Wilson, 1974:55-57; Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:11). Typical westward and eastward current patterns in the project area are illustrated on Figure 5.5-3.

Current speeds change with wind speed, with a few hours lag time (SAIC, 1993:33). Studies of water movements in the coastal waters near Seal Island have shown current speeds ranging from near zero to 27 inches/second (s) (69 cm/s) during the later open water season. Mean open water current speeds were found to be 2 to 5.5 inches/s (5 to 14 cm/s), depending on water column stratification (WCC, 1996:20).

Nuiqsut whaling captains indicated that currents are very strong in early fall and that currents with a southwest wind are most dangerous (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). One whaling captain specifically noted that Seal Island would most likely be affected by the combination of southwest winds and strong currents (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:6-7). Nuiqsut residents also spoke of the difference between currents on the surface and bottom, and stated that the location of currents are unpredictable (Pers. Comm., Nuiqsut Community Meeting August 14, 1996:4).

Surface currents are directed to the right of the wind direction as a result of the Coriolis effect, resulting in a net onshore transport of surface waters in the project area for west or southwest winds. The onshore transport of surface waters is balanced by a return flow of water at depth, resulting in downwelling and mixing along the coast. West winds result in an eastward current of warm, brackish water from the Colville River through Simpson Lagoon/Gwydyr Bay and along the offshore side of the barrier island lagoon system in the project area (Figure 5.5-3). A Barrow whaling captain stated that when the wind hits the top of the ocean and forces the current down and causes it to change, it swirls and creates underwater turbulence (Pers. Comm., Barrow Whaling Captains Meeting, August 28, 1996:1). Combined with the presence of ice, these swirling conditions can be extremely dangerous.

Tables 5.5-1 and 5.5-2 (page 1 of 1)

Figure 5.5-3 (page 1)

Figure 5.5-3 (page 2)

The effectiveness of mixing within the water column is influenced by the physical nature of the seawater. Vertical mixing of the water column is slowed by density stratification of the water column. Easterly winds have been found to induce a high degree of vertical stratification and stability in the nearshore region, slowing the vertical mixing processes. A two-layer structure with lower salinity water due to freshwater from rivers, overlying more marine water is normal during easterly winds. The large density difference between these two layers inhibits mixing. Wind induced surface mixing has little effect on the lower water column during these conditions. Since mixing is limited to the upper layer, surface currents are much greater.

Under west winds, warm, low salinity water collects against the coast, with salinity decreasing and temperature increasing nearer to the shore (Savoie and Wilson, 1986:2-21). Downwelling along the coast tends to reduce vertical stratification of the water column, causing greater vertical mixing. Under sustained west winds (2 to 3 days), the salinity of the eastward longshore flow remains constant, only slowly increasing as winds persist and river flow slows (as snow melt and rainfall decreases). This uniformity was observed in 1983 under west winds from mid-August through mid-September.

Farther offshore within the project area, currents are probably influenced by the eastward flowing "Beaufort Sea Undercurrent," which has been shown to be an important summer feature on the continental shelf seaward of the 160-ft (49 m) isobath extending out to the continental shelf break (Aagaard, 1984:47-72). Nuiqsut residents report that currents change with distance from shore (F. Long, Jr. in USDOI, MMS, 1995:24). One Nuiqsut whaling captain spoke of a strong current he encountered during the fall whaling season offshore of Cross Island, at a distance of about 40 miles (64 km) (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). The location of this current changes every year (F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). Whaling captains observe that whales swim in this strong current, and that the current is strong enough at times to move against the wind (T. Napageak and F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains meeting, August 13, 1996:16). Nuiqsut residents spoke of Seal Island lying close enough to the shore to avoid the zone of major current movement, and that Northstar Island is in a much more dangerous location (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

Under-ice currents in the nearshore project area are driven mainly by water level fluctuations caused by tides and storm surges. A Nuiqsut whaling captain stated that free water is always moving under the ice, especially with a southwest wind (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). Nuiqsut residents involved in spill response drills stated that measurements taken under the ice indicated that current direction could change over relatively short distances (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:9). Limited measurements taken below the ice during the spring of 1976 showed currents on the inner shelf to be slow, never exceeding 3.6 inches/s (9 cm/s), and generally less than 2.4 inches/s (6 cm/s) (Aagaard, 1984:47 to 72). Based on meteorological records and the limited amount of current data, it was concluded that under-ice currents were driven by coastal storm surges and regional circulation patterns.

Very small under-ice currents, generally less than 2 inches/s (5 cm/s), were measured offshore of the West Dock causeway as part of Arco Alaska, Inc.'s NPDES monitoring program in spring 1994 (KLI, 1995:6-5 to 6-8). The predominant direction of flow was westerly, but fluctuated with the tides. Under-ice currents recently monitored offshore of Stump Island, as part of a Northstar project winter test trench investigation, indicated no currents exceeding the 0.84 inches/s (2 cm/s) resolution of the current meter used (Montgomery Watson, 1996:7). However, average under-ice currents of 0.7 inches/s (1.8 cm/s) and maximum under-ice currents of 3.6 inches/s (9 cm/s) have also been reported (WCC, 1997:2-2).

5.5.1.4 Marine Water Quality

Marine water quality in the project area is measured using a number of physical and chemical parameters. The following sections describe these parameters.

Physical Parameters: The temperature of the seawater in the project area is an important component in the oceanographic system. A change in seawater temperature by only a few degrees could result in alteration of the seasonal freeze/thaw cycle within the project area. An essential part of the ecosystem in the project area, ice formation and break up, could be affected if this seasonal freeze/thaw cycle is altered. Density, or mass per unit of volume, affects vertical movement, stratification, and mixing within a given column of seawater. This density is related to both temperature and salinity.

Water column conditions are discussed for the open water period (spring breakup in early June until freezeup in late September to mid-October) and the winter period (October through May). The open water period is subdivided, for descriptive purposes, into three distinct seasons: early, middle, and late.

Early Open Water Season: The early open water season is a time of transition from the ice-covered winter conditions. Runoff from rivers begins in late May or early June with peak flow usually occurring in the first week of June. Wind-driven mixing is at a minimum during the early season as a result of partial ice cover and low wind speeds and wave heights. Seawater is typically stratified during this period with cold marine water in the lower part of the water column and relatively warm estuarine water in the top part. The pycnocline is the junction between these colder and warmer layers, and it typically occurs at 10 to 20 ft (3 to 6 m) of water depth in the project area (WCC, 1997:2-4).

The transition from early to mid-season occurs in late July or early August and is very dramatic. The transition is usually caused by strong east winds that produce a regional upwelling of marine water along the coast. These winds also cause the ice edge to move farther from shore, increasing the wind fetch and mixing due to waves. Easterly winds cause a general inflow of marine water through channels and inlets as a result of the geometry of Simpson Lagoon. This inflow, coupled with surface water division along the coast, causes marine water to enter the lagoon system through deeper channels. The net effect of the first coastal upwelling event each year is to spread surface waters horizontally, allowing greater mixing of shallow waters and passage of marine waters into the lagoon systems. Colder temperatures and higher salinities in the nearshore zone result.

Middle Open Water Season (Mid-season): This season is characterized by disintegration of water column stratification. However, as river discharges decline, coastal conditions approach those of deeper marine waters. Alternating easterly and westerly winds may occur in mid-season and have varying effects on vertical mixing temperature and salinity. As described in Section 5.5.1.3, east winds cause upwelling in the nearshore water column, whereas westerly winds typically result in regional downwelling. Frequent wind reversals increase mixing between coastal and offshore waters, while fewer changes in wind direction (and strength) allow fresher pockets of water to last into late August, with no clear change between middle and late season.

Late Open Water Season: From mid-summer until freezeup, coastal waters become steadily colder and saltier until they are virtually identical to marine waters. Water conditions during the late open water period (early September through October) are relatively constant throughout the region. Temperatures are near freezing throughout the nearshore area. Freezeup of the lagoons usually starts in late September or early October, with shallow offshore areas freezing approximately a month later.

Winter Season: Marine water quality was recently analyzed from samples collected beneath the ice at two locations: in Gwydyr Bay between Point McIntyre and Stump Island, and offshore of Stump Island in 16 ft (5 m) of water (Montgomery Watson, 1996:Table 2). Samples of free water at the Gwydyr Bay location had calculated seawater densities which ranged from 2,990 to 3,226 pounds/yd^3 (1,037 to 1,119 kilograms/m^3) at a water temperature of 25.5°F (-3.6°C). Samples from the offshore location had calculated seawater densities ranging from 2,955 to 3,033 pounds/yd^3 (1,025 to 1,052 kilograms/m^3) at 28.4°F (-2.0°C), indicating that the nearshore waters are generally more dense (saline) than the offshore waters.

Chemical Parameters: Most organisms are dependent upon oxygen in one form or another to maintain metabolic processes. Hence, dissolved oxygen is an important parameter to understand with regard to the health of the marine system. Nutrients, such as nitrogen and phosphate, are also important. pH is a measure of hydrogen ion concentration in seawater and an indicator of the waters' relative acidity or alkalinity. Turbidity is an optical property which describes the interaction between light and suspended particles in seawater. It is frequently used in a qualitative sense to describe the cloudiness caused by sediment suspended in the water.

Dissolved Oxygen: Due to vigorous mixing in the offshore areas by wind and wave action during the open water period, dissolved oxygen concentrations in marine waters along the Alaskan Beaufort Sea coast and in the vicinity of the project area are generally at or near saturation. Dissolved oxygen concentrations for warm, brackish surface waters are similar to values for cold, high-salinity marine waters, although slightly higher dissolved oxygen concentrations are found near the bottom (KLI, 1987:3-8 and 3-9). Typical values for the open water period range from 11 to 13 milligrams per liter (mg/L). Under-ice values around West Dock were found to be high in February through May with concentrations ranging from 9 to 12 mg/L. Dissolved oxygen concentrations under the ice off Oliktok Point during April 1987 ranged from 11.8 to 13.1 mg/L.

Nutrients: Nutrients are compounds of nitrogen and phosphorus that are essential for growth of marine organisms. Nutrient concentrations in surface waters along the Alaskan Beaufort Sea shelf in 1971 and 1972 were generally low, variable, and reached an annual peak in the spring (Schell, 1974:226-228). With an increase in the amount of light in the spring, nutrients are used by ice algae that are beginning to grow on the bottom of the ice.

Nitrogen, in the form of dissolved nitrate is a major nutrient, and elemental nitrogen is essential to all life. River discharges in the spring contribute much of the nitrogen to the coastal waters in the project area (Schell, 1974:226-231). The inorganic nitrogen present at the start of summer is rapidly lessened due to ingestion by plankton. Dissolved organic nitrogen in Simpson Lagoon averaged 5.69 microgram-atoms per liter (µg-at/L). Seaward of the barrier islands, dissolved organic nitrogen had a mean value of 4.86 µg-at/L; nitrate and nitrite were nearly undetectable (Schell, 1974:4-18).

Phosphorus is second only to nitrogen as a nutrient element required by plants and microorganisms. Average phosphate concentrations in Simpson Lagoon and Harrison Bay have been reported at 0.6 to 1.2 µg-at/L with little variation in sample readings (Schell, 1974:229). The lowest phosphate levels occurred near melting ice and nearshore, indicating that neither melting ice nor river runoff were sources of phosphate to the coastal waters. The freshwater in the rivers and deltas is primarily phosphate limited, whereas the coastal marine waters are primarily nitrogen limited which is important for biologic activity.

<u>Hydrogen Ion Concentration (pH)</u>: The pH of water reflects its relative acidity or alkalinity. Although measurements of pH along the Alaskan Beaufort Sea coast are relatively sparse, saline ocean water is a natural buffer that results in fairly constant and similar values throughout a region. In Prudhoe Bay, pH values were 6.8 to 7.9 under the ice, and 7.8 to 8.2 during open water. At Oliktok Point, pH values were 7.5 to 7.7 under the ice, and 7.6 to 8.0 during open water (KLI, 1987:3-10). Offshore of West Dock in 1994, pH values were 8.0 to 8.2 under the ice, and 7.9 to 8.1 during open water. Measurements made in Simpson Lagoon/Gwydyr Bay in August 1970 showed a lower pH, ranging from 7.0 to 7.4 with a mean pH of 7.14 (Alexander et al., 1974:289); however, these data appear to be anomalously low for marine waters.

<u>Turbidity</u>: Turbidity values in the nearshore Alaskan Beaufort Sea area are dependent on wind and wave induced turbulence that resuspends bottom sediment and material discharge from the rivers. The highest turbidity values were found during spring breakup and periods of heavy precipitation when river discharge was high, resulting in turbid plumes that were discharged into the nearshore coastal waters (KLI, 1995:3-10). Turbidity values were found to range from 0 to more than 40 Nephelometric Turbidity Units (NTU), with the majority of the measurements less than 5 NTU. Offshore of the West Dock causeway, turbidity ranged from 3 to 11 NTUs during the open water period, and from 0.5 to 3.4 NTUs during winter under ice conditions. In the offshore portion of the project area that is unaffected by river discharges, turbidity values are expected to be low, similar to those measured offshore of West Dock. Within the inshore portion of the project area, especially Simpson Lagoon where the nearshore waters are influenced by the Kuparuk and Colville Rivers, turbidity values are expected to be higher and dependent on river discharge and sediment resuspension as a result of wave action.

Total suspended solids analyses of recently collected samples from beneath ice at a location offshore of Stump Island in 16 ft (5 m) of water depth, yielded results from non-detectable amounts of solids to 885 mg/L (Montgomery Watson, 1996:11). Samples of free water collected beneath the ice in Gwydyr Bay (between Point McIntyre and Stump Island) showed relatively high total suspended solid values ranging from 7,480 to 26,920 mg/L. Water samples from the same lagoon location, but collected at the ice-sediment interface, were lower in total suspended solids than the free water, ranging from 40 to 3,910 mg/L.

Trace Metals: Trace metals are naturally occurring elements which are present at low concentrations. Trace metal concentrations in marine waters along the Alaskan Beaufort Sea coast and in the vicinity of the project area show no indication of pollution in the water, suspended sediments, or surficial sediments. Trace metal concentrations were determined for seawater samples collected near East Dock in Prudhoe Bay during summer 1979, and were found to be generally low (KLI, 1990:Table 4-2; Boehm et al., 1990:4-1 to 4-11).

Hydrocarbons: Hydrocarbon concentrations in the water column have been found to be low (at l part per billion or less), and appear to be biogenic (biologically derived) in origin (Boehm et al., 1990:4-14 to 4-24).

5.5.2 Environmental Consequences

Impacts to oceanography and marine water quality as a result of development/production activities from the Northstar Unit are discussed in terms of the project phases. Technical topics which build upon issues and background information previously discussed are organized by project alternatives. A description of all alternatives is presented in Chapter 4. Alternatives 2 and 3 are identical with respect to the oceanographic environment and marine water quality and are discussed together. Alternatives 4 and 5 are presented separately to adequately address differences in offshore pipeline routing, length, and landfall locations. Potential impacts from implementation of Alternatives 2, 3, 4, and 5 are summarized in Table 5.5-3.

5.5.2.1 Alternative 1 - No Action Alternative

The oceanographic conditions and marine water quality characteristics would not be affected with selection of the No Action Alternative. The project area is naturally stressed as a result of its arctic location and will continue to be modified by natural forces in the absence of the project. Characteristics of bathymetry, currents, and other oceanographic parameters are not anticipated to change from the current, natural setting. Overall, no impact to the oceanographic or marine environments would occur.

5.5.2.2 Alternatives 2, 3, 4, and 5

The offshore portions of Alternatives 2 and 3 are identical and would require approximately 6 miles (9.6 km) of offshore pipeline trench. Therefore, environmental consequences to oceanography and marine water quality for Alternatives 2 and 3 are identical.

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The submarine pipeline under Alternative 4 is routed south from Seal Island as it is under Alternatives 2 and 3, but turns southeast approximately 3 miles (4.8 km) south of the island. The pipeline skirts to the north of the barrier islands and turns southwest to reach land on the coast at Point McIntyre. Under Alternative 4, the total length of the offshore pipeline would be 9 miles (14.5 km).

The submarine pipeline route under Alternative 5 skirts north of the barrier islands similar to the route under Alternative 4, but lands at Dock 2. Under Alternative 5, approximately 3.8 miles (6 km) of pipeline corridor would be located in water depths of between 0 and 10 ft (0 to 3 m), approximately 3.4 miles (5.3 km) of pipeline corridor would be located in water depths of between 10 and 20 ft (3 and 6 m), and approximately 1.8 miles (2.9 km) of pipeline corridor would be located in water depths of between 20 and 40 ft (6 and 12 m). The total length of the offshore pipeline would be 8.9 miles (14.3 km).

Construction Impacts: The marine environment would be affected by island reconstruction and trenching and burial of offshore pipelines. The production island would be built over the existing Seal Island site, requiring emplacement of between 700,000 and 800,000 yds^3 (535,185 and 611,640 m^3) of additional gravel to the existing island footprint. A submerged protective gravel berm 50 to 100 ft (15 to 31 m) wide would be placed around the north, west, and east sides of the island. Based on the fact that the reconstruction will not create a new structure, but rather elevate and enlarge an existing one, impacts to bathymetry in the immediate vicinity of Seal Island are considered to be negligible as a result of island reconstruction.

Reconstruction of Seal Island would affect water quality in a number of ways. Increases in turbidity and suspended sediment concentrations in the immediate vicinity of the island during gravel dumping activities are anticipated. Density of the water column and winter season stratification might be altered due to the artificial mixing produced by the gravel dumping. However, due to the relatively short, 3-month duration of gravel placement activities, effects to marine water quality are expected to be short-term and negligible.

Summer construction activities such as grading and shaping the island and sub-sea island slopes would result in re-suspension of sediments, causing localized temporary increases in turbidity and suspended sediment concentrations in the water column. These increases in turbidity and suspended sediment would have minor impacts to marine water quality.

In early spring, excavations for installation of marine outfalls and the seawater intake system would be carried out below sea level. Dewatering activities would involve a discontinuous and variable discharge of up to 1,389 gallons (5,258 liters) per minute. The water discharged early in the dewatering process would have an elevated suspended sediment load, and would result in a turbid discharge. However, the discharge would be discontinuous and short-term, (2 to 4 weeks); therefore, impacts would be considered minor.

Pipeline trenching and subsequent backfilling activities would result in suspension of sediment into the water column. The amount of suspended sediment and plume size would depend on sediment grain size and cohesiveness characteristics and under-ice currents. The effects on water quality would vary along the pipeline route. In the inshore area of bottomfast ice (less than 6-ft [1.8 m] water depth), little or no water would be expected between the ice and sediment, and as a result, no impacts to long-term water quality would occur.

In the offshore area where water would be present between the ice and sediment, water quality would be temporarily affected by trenching and backfilling activities. The extent of sediment resuspension would depend on the water depth, sediment grain size and cohesiveness, strength of the currents, and the amount of sediment released during dredging and backfill operations. An offshore test trench was excavated for the project during March 1996, and total suspended solids concentrations were found to range from only approximately 20 to 40 mg/L above background at distances of up to 1,000 ft (305 m) from the excavation (Montgomery Watson, 1996:Tables 1 and 2). Based on data from this test, Montgomery Watson computed a maximum probable distance of 830 ft (253 m) for under ice sediment plume transport. However, due to the relatively short, 4- to 5-month, duration of pipeline trenching activities, impacts to marine water quality are expected to be localized and temporary in nature and, therefore, have a negligible impact to long-term water quality.

Excess spoils generated from trenching and pipeline installation activities would be disposed on the ice at a location immediately outside the barrier islands over floating-fast ice. The expected volume of excess spoils is approximately 5,000 yd^3 (3,823 m^3), with a maximum quantity of up to 65,000 yd^3 (49,696 m^3). This maximum 65,000 yd^3 (49,696 m^3) spoils volume would only occur if pipeline construction was terminated due to hazardous conditions. The excess spoils will be spread and leveled such that their release, temporary suspension in the water column, and deposition on the seafloor during breakup would be uniform. It is anticipated that these excess spoils will be further scattered and distributed by natural ice and current processes during breakup the following year. The release of the excess spoils during breakup is expected to occur over a period of weeks. The volume of excess material is relatively small (5,000 yd^3 [3,823 m^3]), less than two average days of sediment yield from the Kuparuk River during spring breakup and summer flows (USDOI, GS, 1996:Table 1) and its release will occur only once. The impact to marine water quality and bathymetry from the release of the excess spoil material is considered to be negligible. Impact would be considered to be minor even in the event that all excavated trench material (65,000 yd^3 [49,696 m^3]) was disposed as excess spoil. Within the range of potential spoil disposal from expected to worst case, it is anticipated that natural ice dynamics and other oceanographic processes (e.g., currents) would quickly scatter the spoils. A slight but measurable short-term bathymetric mound could develop. Over the course of several years, or less, these processes would continue to erode any mounds until they were indistinguishable from other naturally occurring seafloor features.

Under Alternative 5, nearshore gravel placement would also be required. Gravel placement would occur along the west side of the West Dock causeway between Dock 2 and the West Dock Staging Pad to accommodate the pipeline route. Between 290,000 and 300,000 yd^3 (221,719 to 229,365 m^3) of gravel would be used to widen the existing causeway by approximately 50 ft (15 m). The new gravel would be placed immediately adjacent to the existing causeway and would match the existing causeway in height. Due to the nearshore nature of the area and its typical bottomfast ice, little or no water would be expected between the ice and sediment, and as a result, no impacts to long-term water quality would occur as a result of the causeway expansion.

Operation Impacts: Once reconstructed, Seal Island would alter water current patterns in the immediate vicinity of the island. Prevailing current direction could be altered slightly as flow is diverted around the island. However, because the perimeter footprint which currently defines the island boundaries would not be substantially increased during the reconstruction, increases in current patterns and velocities in the vicinity of Seal Island will be small, localized, and of negligible impact to project area and regional oceanography.

Nuiqsut whaling captains have observed that the combination of current, storm surges, and "young" ice create hazardous conditions where ice override could affect Seal Island facilities (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996). Structural design criteria for Seal Island includes features specifically intended to protect the integrity of the facilities both on the island and onshore in the event of a storm surge. The predicted storm surge values used for design purposes were 6 ft (1.8 m) for onshore and 4 ft (1.2 m) for Seal Island. Design criteria are based on a 100-year return interval. Operation impacts of ice override are discussed in Section 5.6.2.2.

The Alternative 5 pipeline route is within 500 ft (150 m) of the 650-ft (195 m) breach in the causeway which connects West Dock with the mainland. Increased sediment scour at the breach could lessen the integrity of the pipeline's protective embedment. Since its installation, bathymetric surveys have been conducted annually at the breach to monitor the effects of current scour around the piles which support the bridge structure. Surveys indicate that scour in the vicinity of the piles has increased as a result of the structure, and that the presence of the structure has altered the bathymetry in the immediate area. The magnitude of the scour, however, is an order of magnitude less than predicted. Survey data from 1995, 1996, and 1997 indicate that maximum scour depth in the vicinity of the breach has not exceeded 3.3 ft (1 m) in any given year (CFC, 1995: Drawing CFC-346-001; CFC, 1996:Drawing CFC-359-001; ARCO, 1997:Sketch WDBBATH). Based on a comparison of the 1997 bathymetric scour data and design specifications which allow for scour depths up to 40 ft (12 m), a 3.3-ft (1 m) rate of accelerated marine sediment scour annually is considered minor. It is possible that scour impacts to pipeline backfill material would be slightly greater in the vicinity of the West Dock causeway breach. However, impacts to the integrity of the backfill protecting the pipeline as a result of scour will be minor.

Support vessel operations and permitted discharges will affect marine water quality in the project area as a result of operations. Support vessels, barge traffic, and periodic sea lifts would generate propeller wash and turbulence along the south side of Seal Island where the dock face would be located and at West Dock where vessels and barges would be originating. These vessel operations would result in re-suspension of finer sediments in the immediate vicinity of the dock heads at Seal Island and West Dock. The region of elevated suspended solids and turbidity would be mainly confined to the area within the wake of the vessels as they traverse the shallower waters. The limited areal extent of operationally induced re-suspension of fine sediments related to seasonal vessel traffic to and from Seal Island would result in a negligible impact on water quality in the project area.

No drilling muds, borehole cuttings, or produced water are proposed for discharge to the marine environment. The two proposed marine outfalls related to operational activities are: 1) a combined stream composed of system flush water, brine effluent associated with the potable water system, and treated domestic/sanitary wastewater; and 2) seawater discharged through the fire suppression system during annual tests. The source of feed water for these operational outfalls is seawater collected through a seawater intake system. This seawater is utilized by various facility operations.

The continuous flush system is designed to prevent ice formation and biofouling, while the desalination brine is a byproduct of the potable water system that renders freshwater from seawater. The freshwater produced is utilized for both human and operational activities. Domestic/sanitary wastewater, following an activated sludge and ultraviolet treatment, is generally discharged through a class I industrial disposal well but may occasionally be marine discharged; this treated wastewater stream results almost exclusively from human activities related to food preparation, consumption, and bathing, and does not contain any fluids related to the oil production/processing systems. The above streams are commingled prior to marine discharge and Alaska State Water Quality Standards are satisfied within 16.4 ft (5 m) of the discharge point; therefore, negligible impacts to water quality from these discharges are expected.

Annual tests of the fire suppression system would require discharge of 88,200 gallons (333,873 liters) of seawater over a 30-minute test period. Discharge of ambient seawater is considered to be a negligible impact on water quality.

The above discharges are not expected to impact the island's intake water quality, i.e, the discharge ports are so located to ensure discharged waters do not recycle back into the seawater intake. In addition, these discharges do not contain excessive quantities of pollutants that might bioaccumulate in marine organisms and, therefore, cannot result in elevated levels of toxic or carcinogenic pollutants in marine organisms consumed by humans. Additional details are provided in Appendices G and H.

Some effect to marine water quality would be expected should there be an oil spill in the project area. Dissolution and dispersion of hydrocarbons in the water column could temporarily cause exceeded chronic levels of water quality criteria in waters contacted by oil. Impacts of oil to water quality are also discussed in Chapter 8.

Maintenance Impacts: The island surface will be re-graded to design contours on an annual basis following spring breakup. Should additional gravel be needed it will be mined from an onshore source and transported to the island by barge during the summer months. Annual maintenance of the island may include regrading of the island work surface prior to freezeup to ensure spring runoff and snowmelt will be directed toward the catchment basins. Re-grading activities will not affect marine water quality in the immediate vicinity of the island. All re-grading activities will occur above sea level, thus the marine environment will not be impacted.

The linked-concrete slope protection system which protects the slope of the island will be regularly inspected both above and below the waterline. Above waterline repairs will not affect the marine water quality. Repair actions below the waterline will be of short duration. Minor increases in suspended sediments and in turbidity are possible, but not likely with respect to these repairs. Impacts to marine water quality from repair actions below the water line are expected to be negligible.

The sacrificial gravel berm at the toe of the slope is not slope-protected and, therefore, is subject to erosion. It is anticipated that subsurface currents and wind and wave action will scour the gravel berm in such a manner that the loss of gravel on one side of the island will add to the volume of gravel on the other side of the island. The preferred berm replenishment option involves "backpassing" or relocating the berm gravel from areas of deposition to areas of erosional loss (BPXA, 1997:3.2-3). Backpassing would likely involve localized increases in suspended sediment and turbidity. Increases would be short-term, one to two weeks, and the affected area limited to the immediate vicinity of the island. Thus, impacts from berm replenishment are considered minor.

In the event that repairs to the offshore pipeline are required, sediment would be locally disturbed. However, this disturbance could increase total suspended solids and turbidity in the marine water. This increase would occur infrequently over short periods of time, and, therefore these activities would have a minor impact to offshore marine water quality.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts would be expected to be similar to those generated during construction, and the overall impact to marine water quality from abandonment would be expected to be minor.

5.5.3 Summary of Environmental Consequences

Potential impacts summarized in this section were identified through an analysis of the project alternatives. No unavoidable adverse effects or impacts with respect to physical oceanography or marine water quality were identified as a result of implementing the proposed project. This includes any direct and indirect impacts due to construction activities, operational activities (with the exception of a large oil spill), maintenance procedures, and abandonment options. In the event of an oil spill, minor impacts to marine water quality, as measured in the water column, are predicted to occur, particularly near the oil sheen. The degree of impact would be a function of spill size and season. Potential environmental impacts resulting from an oil spill are discussed in detail in Chapter 8.

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- Long, Frank, Jr.

- Napageak, Thomas

5.6 SEA ICE

5.6.1 Affected Environment

The offshore project area is ice-covered for 9 to 10 months of the year, making sea ice a dominant, decision-driving marine feature within the project area. Even during summer months, onshore winds occasionally bring icebergs and ice floes into the project area from the permanent polar pack ice to the north. Information about sea ice and its potential effects on the project are presented in this section. This information is also used to support the NPDES Permit and associated fact sheet (Appendices F, G, and O), and the Ocean Discharge Criteria Evaluation document (Appendix H), and Section 103 Evaluation (Appendix I) for this project.

5.6.1.1 Ice Formation

Sea ice is formed from the ocean surface downward. Growth of sea ice is controlled by atmospheric conditions such as air temperature and cloud cover; by marine conditions such as the roughness of the sea, currents, water depth, and salinity; and by the amount of snow cover over ice. Multi-year sea ice survives more than two summers. Multi-year sea ice sheets are typically 7 to 13 ft (2 to 4 m) thick.

The Alaskan Beaufort Sea can be divided into three sea ice zones: the landfast ice zone, shear ice zone (stamukhi), and polar pack ice zone. These sea ice zones, which exist as bands parallel to the shoreline, are shown on Figures 5.6-1 and 5.6-2.

Landfast Ice Zone: *Landfast ice* is connected directly to the shoreline. The landfast ice zone follows the mainland coastline and is made up mostly of first-year bottomfast ice and floating-fast ice (Figure 5.6-1). *Bottomfast ice* is frozen to the seafloor to water depths of approximately 6.6 ft (2 m) and usually remains motionless and relatively undeformed during the winter, both inside and outside of the barrier islands (BWA, 1983:6) (Figure 5.6-3). *Floating-fast ice* is floating ice that generally extends outward from bottomfast ice. It typically occurs at water depths of 6 to 65 ft (2 to 20 m) (SOHIO, 1984: 6.4.1.1; USDOI, MMS, 1996:Fig. III.A.4-1), i.e., extending to about 4 to 8 miles (6 to 13 km) seaward of Seal Island. The project lies within the landfast ice zone. The seaward extent of the landfast ice zone (Figure 5.6-2) varies with the time of year, the amount of protection offered by the coastline, water depth, and the strength of forces that seasonal and polar pack ice exert on the landfast ice (Kovacs and Mellor, 1974:117).

Leads are gaps between ice sheets that occur on the seaward edge of the landfast ice zone. Leads separate the landfast ice zone from the shear and pack ice zones, and open and close as the shear ice zone moves in response to winds and/or currents moving the polar pack ice. Leads have open water for variable periods of time before freezing over with thin, new ice. The new ice then fractures and piles into ridges when the lead closes (Weeks, 1976:184).

Shear Zone: The *shear zone* is the boundary between the moving polar pack ice and the fixed landfast ice. Also referred to as the *stamukhi zone*, it is characterized by drifting ice floes and open water leads. The seaward extent of the shear zone can extend to the edge of the continental shelf, approximately 60 miles (97 km) offshore from the project area (Kovacs and Mellor, 1974:116); however, it is difficult to define due to the effect of local seafloor changes, as well as seasonal changes in the polar pack ice zone (SOHIO, 1984:6.4.1.1).

The shear zone is the most dynamic of the three sea ice zones due to influences from the polar pack ice and its response to wind and currents (Kovacs and Mellor, 1974:123). Movement of the polar pack ice is the major cause of open leads and pressure and shear ridges within the shear zone (Kovacs and Mellor, 1974:124). *Pressure* and *shear ridges* are linear accumulations of ice rubble caused by the compression between ice floes and sheets. Ridges are usually straight, often extend tens of miles in length, and may be up to 13 ft (4 m) high. Pressure and shear ridges primarily occur in the shear zone; however, they also are formed within the floating-fast sea ice zone during seasonal freezeup when the ice cover is thin. If pressure from the pack ice is relatively high, broken ice and rubble may be pushed into pressure ridges with ice keels that extend to the seafloor (Kovacs, 1976:3) (Figure 5.6-4) within the floating-fast ice zone in which the project is located. This is an important consideration for submarine pipelines. The most powerful direction of drifting ice within the shear zone in the project area is east to west (Kovacs and Mellor, 1974:114) due to winds and ocean currents.

High winds during storms and ocean currents are the main forces that cause pressure and shear ridge formation. Frequency and magnitude of storms decrease as winter progresses, thus, the potential for extensive ridge formation is less during late winter (Kovacs, 1976:3). The correlation between ridge formation and wind was observed by a Barrow elder, who reported ridge creation even after the ice has reached substantial thickness (O. Ahkivgak in NSB, 1980:100).

Polar Pack Ice Zone: The polar pack ice zone lies beyond the continental shelf and is outside the project area. The polar ice pack influences the sea ice conditions within the project area because it collides with and moves floating ice within the project area. Nuiqsut whaling captains report that the polar ice pack does not reach Seal Island because it is too heavy and becomes grounded before it gets there (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). Generally, it is visible from the project area, but occasionally remains so far out that the whaling captains cannot see it (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:11).

The polar pack ice zone influences the formation and movement of the shear and landfast ice zones. As described in Section 5.4, easterly winds prevail during summer, tending to keep the polar pack ice far out to sea, while westerly storm winds that dominate the winter season tend to push the polar pack ice towards the coast (GRI, 1992:7; Kovacs and Mellor, 1974:114). Occasional westerly winds during ice-free summer months can bring ice floes or icebergs from the polar pack ice zone to shore or inside of the barrier islands.

An understanding of ice strength is important in the scope of the project because many of the winter season tasks, including gravel hauling, island reconstruction, and pipeline installation will be accomplished using an ice road. In addition, reconstructed Seal Island would be subjected to ice force seasonally throughout the duration of the project. Strength of sea ice varies widely and primarily depends on salinity, temperature, and thickness, all of which are briefly discussed below.

Salinity: Ice strength is related to salinity (salt content). The lower the overall salinity of a sea ice sheet, the higher the effective strength. Salinity of a sea ice sheet usually is higher at the bottom than on the surface (Weeks, 1981:B-5). Salinity of Alaskan Beaufort seawater is typically 30 to 35 ppt, and newly formed first-year sea ice has a salinity of 12 to 15 ppt. As first-year ice thickens and ages, salinity decreases to 4 to 5 ppt by the end of a year's growth (Weeks, 1976:178). This decrease in salinity occurs when pockets of brine, which do not freeze, move downward through thaw branches and channels in the ice sheet by gravity and concentration gradients (Gerwick and Sakhuja, 1985:12). Brine channels and pockets reduce the percentage of ice-to-ice bonding, thus reducing the effective strength of the ice (Weeks, 1976:177)

Figure 5.6-1 (page 1 of 2)

Figure 5.6-1 (page 2 of 2)

Figure 5.6-2 (page 1 of 2)

Figure 5.6-2 (page 2 of 2)

Figure 5.6-3 (page 1 of 2)

Figure 5.6-3 (page 2 of 2)

Figure 5.6-4 (page 1 of 2)

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Temperature: The temperature of a sea ice sheet has a large effect on its mechanical properties. The temperature at a given time and location varies with atmospheric conditions, such as air temperature, wind speed, and snow cover. Cold sea ice exhibits greater effective strength than warm sea ice. However, sea ice is brittle at low temperatures and elastic at warmer temperatures (Gerwick and Sakhuja, 1985:14). Therefore, mid-winter, cold sea ice will be stronger and more brittle than early fall or late spring (freezeup or breakup) sea ice. Conversely, weak sea ice in early fall or late spring is subject to large deformations and ridging.

Thickness Effect: The strength of a sea ice sheet, whether first-year or multi-year, is related directly to its thickness. Overall ice strength increases as thickness increases, because of the larger cross-sectional area that is available to withstand force. Internal stresses and pressure are greater within a thicker ice sheet, producing higher effective strength per unit thickness.

5.6.1.2 Ice Season

The Alaskan Beaufort Sea is never completely free of sea ice. However, 43 years of data in the project area indicate open water conditions exist for 60 to 86 days of the year. Polar pack ice typically is present within approximately 75 miles (121 km) offshore, even in summer. The ice season varies from year-to-year depending on climate and air temperature ranges. The average length of the ice season in the project vicinity is approximately 300 days, based on observations from a number of sources summarized by INTEC (1996a:3-7), and an Inupiat resident commented that sea ice is generally present 9 months of the year (J. Nukapigak in USDOI, MMS, 1995:15-16).

The annual ice cycle within the nearshore area of the Alaskan Beaufort Sea is described in Table 5.6-1. Historical data from 1953 to 1975 shows that breakup can begin in the project area as early as mid-June, with most breakup periods beginning in early July (Cox and Dehn, 1981:806). Additional information regarding the occurrence and movement of ice floes during summer is presented in Section 5.6.1.3. Historically, freezeup has begun as early as mid-September, with the average start of freezeup occurring in mid-October.

5.6.1.3 Ice Sheet Movement

Winds and currents are the main factors affecting the movement of Alaskan Beaufort Sea ice. Storm winds can cause changes in movement and are usually the reason ice sheets come into contact with a structure or another ice sheet. Conversely, the influence of strong currents can cause sea ice to move against the wind.

Inupiat residents consider October through December to be the period when ice movement hazards are most critical offshore of Nuiqsut and near Cross Island. Unpredictable conditions during this period result in elders warning hunters not to go out because of the risk involved (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:1-3).

Table 5.6-1 (page 1 of 1)

The floating-fast ice sheet moves back and forth perpendicular to shore with the daily tides, averaging movements of about 3 inches/day (8 cm/day). Floating-fast ice motion usually is greater seaward of the barrier islands (OSI, 1980d:8). Ice just north of Northstar Island moved a net distance of 9.3 ft (2.8 m) to the west during a 4-month study in 1980. Maximum movement rates observed during the study were 10 inches/hour (25 cm/hour) (OSI, 1980a:5). Horizontal ice movement has been predicted to occur in the project area at a maximum rate of 6.6 ft/day (2 m/day) for water depths less than 40 ft (12 m) (INTEC, 1996a:3-43). The median ice movement rate near Seal Island is less than 1-ft (0.3 m) per day (Agerton, 1982: 2.1). Polar pack ice in the Arctic Ocean is in constant motion due to a current known as the Beaufort Gyre (Vaudrey, 1985b:46). Ice island pieces and icebergs are sighted in the project area occasionally, and may remain adrift in the Beaufort Sea for years. A study of multi-year ice movements conducted in 1984 and 1985 found that ice drift averaged 13.4 nautical miles/week (24.8 km/week) for most of the study year (ARCTEC, 1985:1). Ridges and floes displayed greater, storm-induced movements, averaging 37.6 nautical miles/week (70.2 km/week) during the fall months (September, October, and November).

The vertical movement and inundation by seawater of landfast ice due to tides or storm surges has been noted by whaling captains (F. Long, Jr. and T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8). Inupiat who travel over ice sheets watch for formation of open leads which cause ice movement and open water hazards. Leads are unpredictable and appear in different places every year. They also open and shut quickly, which is the main reason there is no spring whaling in Nuiqsut (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2). Major ice movements may occur within 2 or 3 minutes of a large wind change (B. Pausanna in USDOI, MMS, 1995:41).

Although open water usually extends from the shoreline to Seal Island by mid-July (INTEC, 1996a:3-9), wind, currents, and storm surges can move multi-year ice floes into the project area. Ice floe concentrations are expected to occur on 3 to 18 days of the open water season (INTEC, 1996a:Table 3-7). Larger ice floe invasions covering more than 1/10th of the sea surface during the open water season typically occur once every 4 to 5 years.

Inupiat residents consider the ice to be much more dangerous in the deeper, faster moving waters offshore of Cross and Northstar Islands, than inshore of Seal Island and the barrier islands because of active ridge formation and movement in the shear ice zone (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). Ice coming from the north forming pressure ridges is not considered as dangerous as ice that moves from side to side, particularly from southwest to east (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2).

5.6.1.4 Ice Forces on the Local Environment

Sea ice events, such as ice gouging, strudel scour, and ice ride-up, can cause hazardous conditions or damage within the project area.

Ice Gouging: Ice gouging is the most severe environmental hazard that may be encountered by underwater structures in shallow regions of the Alaskan Beaufort Sea (Walker, 1985:9). Ice gouging

(Figure 5.6-4) is caused by the movement of grounded ice keels within pressure ridges, as well as within icebergs and ice islands, moving in response to wind and currents (Walker, 1985:15). Ice gouging in the landfast sea ice zone is most common during breakup and freezeup, when the ice cover is unstable and highly mobile. In the shear zone (Figure 5.6-1) most grounding occurs in the winter from ridge keels, and gouging can occur any time of year from multi-year pressure ridges or ice islands (Walker, 1985:16). Small ice keels typically produce narrow gouges in shallow waters, and large ice keels produce wide gouges in deep water (Walker, 1985:15). In studies conducted in the Alaskan Beaufort Sea between 1972 and 1979, the deepest gouge observed was 8.5 ft (2.6 m) deep below the seafloor in 125-ft (38 m) deep water. Inside protected lagoons, the deepest gouge observed was 2.3 ft (0.7 m) deep (Weeks et al., 1983:26).

Sonar records and diver observations have revealed that much of the Alaskan Beaufort seafloor is marked by ice gouges (Weeks et al., 1983:1). A graphical representation of gouge depth compared to water depth for the project vicinity is presented on Figure 5.6-5. Ice gouging is particularly heavy in the shear zone at the seaward edge of the barrier islands' landfast ice zone (Figures 5.6-1 and 5.6-2) in water depths of 50 to 66 ft (15 to 20 m) (Weeks et al., 1983:3). The maximum water depth where ice gouging has been recorded is 155 ft (47 m) (Walker, 1985:16). Shallow water and barrier islands block the invasion of large, consolidated ice floes, thus reducing gouging in those areas. The highest potential for ice gouge formation in the project area is in the offshore area from Long and Stump Islands to Seal Island (INTEC, 1997a:7).

Ice gouges can be measured using "gouge intensity," which can be defined as an estimate of the amount of visible sediment disruption. Gouge intensity is calculated by multiplying gouge density over an area of seafloor by maximum gouge depth and width (Norton and Weller, 1984:188). Higher gouge intensities suggest a higher potential for sediment disruption from ice gouging. Gouge intensities mapped along the Alaskan Beaufort Sea shelf are shown on Figure 5.6-6. The project area inside the barrier islands, as well as between the barrier islands and Seal Island, is considered to have a low gouge intensity (Norton and Weller, 1984:202), with gouges to maximum depths of approximately 1.6 ft (0.5 m) (Norton and Weller, 1984:201). Gouge intensity offshore of Seal Island is considered medium to very high, with gouges to maximum depths of 6.6 ft (2 m) (Norton and Weller, 1984:201 and 202). Gouge survey data collected during summer 1995 in the project area indicated a maximum gouge depth of 2 ft (0.6 m) in water depths of 32.5 ft (9.9 m) (Leidersdorf and Gadd, 1996:1). Estimates of 100-year event ice gouge depths in the project area indicate potential gouges to approximately 3.5 ft (1.1 m) (INTEC, 1997a:18,19).

Strudel Scour: Strudel scour is the process where water flowing through holes or cracks in the ice erodes the seafloor. During the early stages of breakup (late May to early June), landfast sea ice near the river deltas becomes overflooded with meltwater from rivers and inland drainages. Downward seepage or drainage of this overflooded water through the sea ice sheet, which results in strudel scour, typically occurs in the region between the 6.6- to 16-ft (2 to 4.9 m) water depth contours. Initially, most scours form a short distance beyond the bottomfast ice (Walker, 1985:46; Vaudrey, 1985a:10). Scour holes are formed in the seabed

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below the drain holes in the ice (Figure 5.6-7). Strudel scour typically occurs within 10 miles (16 km) of river mouths along the Alaskan Beaufort Sea coast (Figure 5.6-8).

Surveys conducted in 1985, 1995, and 1996 in the project area detected scours in water depths of 6 to 20 ft (1.8 to 6 m), with maximum horizontal dimensions in the range of 20 to 89 ft (6 to 27 m), and a maximum scour depth of 5.7 ft (1.7 m) (HLA, 1986; Leidersdorf and Gadd, 1996:3). Results indicated the highest probability of strudel scouring is in 15- to 20-ft (4.6 to 6.1 m) water depths, but the largest scours occur in 6- to 10-ft (2 to 3 m) depths (INTEC, 1997c:11,12). Strudel scour (Vaudrey, 1985a:14) can create deeper depressions in the seabed than ice gouging, making scour an important consideration in the design of the submarine pipeline.

The Kuparuk River overflood region is constrained by barrier islands, which effectively contain most flood waters within Simpson Lagoon. Strudel scouring generally does not occur in areas of bottomfast ice such as Simpson Lagoon, but does occur in water depths greater than 6 ft (1.8 m) where waters drain through floating-fast ice (Vaudrey, 1985a:11). The total number of strudel scour features in the Kuparuk River region during 1984 was estimated between 40 and 50 (Vaudrey, 1985a:11-12).

Ice Pile-up and Ride-up: Ride-up refers to the horizontal movement of ice onto the shore, and pile-up refers to the vertical buildup of ice piled at the shore. Sea ice ride-up and pile-up, also referred to as ice override, occurs along the coastlines, mainland shores, and offshore islands in the project area. Ice sheets, driven by storm winds or currents, either ride-up or pile-up the slopes of beaches at the shoreline of the mainland and barrier islands, as well as manmade islands (SOHIO, 1984:6.4.3). Sea ice sheets shift and move whenever ice covers the Alaskan Beaufort Sea, but large movement events typically occur during freezeup or breakup when the sea ice sheet may be thin, deteriorated, or detached from the coastline. Sea ice ride-up can push aside beach and tundra material, potentially resulting in impact damage to coastal structures.

The Inupiat observe that the polar ice pack provides the force that drives first-year ice from 1 to 2 ft (0.3- to 0.6-m) thick over sizeable barriers with great speed and force. Often this condition results from a combination of storm, current, tide, and ice, particularly under a southwest wind (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). Generally, the wind is the main force that causes major ice override (O. Ahkivgak in NSB, 1981:100). Kaktovik residents indicated that powerful ice movements can occur even without the contributing factor of wind, because currents in their area are extremely strong and swift (H. Rexford in USDOI, MMS, 1979:49; J. Ningeok in USDOI, MMS, 1990:19-20). When there is a strong southwest wind, combined with current direction from west to east, and high tide, ice can move in a west to east direction at relatively high speeds, accompanied by elevated water levels. These conditions are most likely to occur during the months of October through December (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996).

When moving sea ice sheets contact steep slopes or bluffs, failure occurs in a buckling or bending mode, causing pile-up events. It is possible for pile-up to occur at a height sufficient to allow sea ice blocks at the top of the pile to fall onto structures along the shore. Additionally, drifting snow or ice pile-up may form a ramp allowing ice to ride-up over vertical bluffs or sheet pile walls (CFC, 1996:2; Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996).

The Inupiat regard ice override as a potential hazard. Nuiqsut whaling captains indicated that ice override, though infrequent, may occur at any time and with little warning (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). Nuiqsut residents were, however, generally less concerned about ice override near Seal Island, which is in the more stable landfast ice zone, than those hazards near Northstar Island shoal, which is near the shear ice zone (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2).

Studies indicate ice ride-up and pile-up is minimal near Point Storkersen due to protection from ice movement from the barrier islands and shallow water in Simpson Lagoon. Additionally, ride-up and pile-up has not been documented on the shoreward side of Stump or Egg Islands, or along the coastline between the Kuparuk River and Point McIntyre (INTEC, 1996a:3-23). However, Nuiqsut whaling captains have observed that southwest winds, combined with current and moving ice, affected barges moored in nearshore areas near Prudhoe Bay, inside the barrier islands (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:2).

Ice pile-up data was summarized for offshore islands in the project vicinity for six freezeup seasons (1980-85) (INTEC, 1996a:3-23). Pile-up heights of 10 ft (3 m) on the offshore side of Stump Island and 20 ft (6 m) at Seal Island were reported. Based on the frequency distribution of data for these islands and others in the project vicinity it was predicted that a maximum ice pile-up height of 56 ft (17 m) could occur as a 100-year event at Seal Island (INTEC, 1996a:3-24). Ice pile-up predictions are an important consideration when designing offshore structures such as Seal Island.

5.6.2 Environmental Consequences

Potential impacts of each project alternative (described in Chapter 4) to sea ice and potential hazards to the project which may result from sea ice are discussed below. Alternative 1 is presented first. Alternatives 2 and 3 are identical with respect to sea ice and are presented together. Alternatives 4 and 5 are discussed separately to adequately address differences in pipeline routing, pipeline length, and pipeline landfalls. Issues for alternatives are related to project phases (construction, operation, maintenance and abandonment). Potential impacts of Alternatives 2, 3, 4, and 5 are summarized in Table 5.6-2.

5.6.2.1 Alternative 1 - No Action Alternative

Sea ice would not be affected with the selection of the No Action Alternative. The project area is naturally stressed as a result of its arctic location and will continue to be modified by natural forces in the absence of the Project. No impacts to sea ice result from the adoption of Alternative 1.

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5.6.2.2 Alternatives 2, 3, 4, and 5

Under Alternatives 2 and 3, approximately 2.4 miles (3.8 km) of pipeline corridor would be located in water depths of 0 to 10 ft (0 and 3 m), approximately 1.7 miles (2.8 km) of pipeline corridor would be located in water depths of 10 to 20 ft (3 and 6.1 m), and approximately 1.8 miles (2.9 km) of pipeline corridor would be located in water depths of 20 to 40 ft (6.1 and 12.2 m). The total length of the offshore pipeline would be 6 miles (9.6 km). The marine portions of Alternatives 2 and 3 are identical. Likewise, the potential impacts of both project alternatives on sea ice conditions, as well as sea ice forces on both alternatives, are comparable.

The submarine pipeline under Alternative 4 is routed south from Seal Island as it is under Alternatives 2 and 3, but it turns southeast approximately 3 miles (4.8 km) south of the island. The pipeline then skirts north of the barrier islands and turns southwest to land on the coast between Point McIntyre and West Dock. Under Alternative 4, approximately 3.9 miles (6.3 km) of pipeline corridor would be located in water depths of 0 to
10 ft (0 to 3 m), approximately 3.3 miles (5.3 km) of pipeline corridor would be located in water depths of 10 to 20 ft (3 to 6.1 m), and approximately 1.8 miles (2.9 km) of pipeline corridor would be located in water depths of 20 to 40 ft (6.1 to 12.2 m). The total length of the offshore pipeline would be 9 miles (14.5 km).

The submarine pipeline route under Alternative 5 skirts north of the barrier islands similar to the route under Alternative 4, but landfall is at Dock 2. Under Alternative 5, approximately 3.8 miles (6.1 km) of pipeline corridor would be located in water depths of 0 to 10 ft (0 to 3 m), approximately 3.3 miles (5.3 km) of pipeline corridor would be located in water depths of 10 to 20 ft (3 to 6.1 m), and approximately 1.8 miles (2.9 km) of pipeline corridor would be located in water depths of 20 to 40 ft (6.1 to 12.2 m). The total length of the offshore pipeline would be 8.9 miles (14.3 km).

Construction Impacts: Offshore construction, including reconstruction of Seal Island and installation of the offshore buried pipeline, would occur during winter. Construction activities during this period would include preparation of ice roads, offshore transport of gravel over an ice road to Seal Island, offshore pipeline installation and initial drilling. Construction activities associated with the island slope protection and infrastructure installation would take place during the open water season.

Gravel would be mined onshore and hauled offshore to a temporary stockpiling area near Egg Island and then transported to Seal Island for reconstruction. Under Alternative 5, gravel will also be placed to widen the West Dock causeway. Ice thickness would be increased for use as an ice road near the mouth of the Kuparuk River and along the route to be used for gravel hauling from the quarry to Seal Island. Ice disturbance as a result of this activity is limited to thickening and vertical ice movement and would be short-term and limited to the immediate vicinity of the ice road and temporary stockpile area at Egg Island. Impact to sea ice as a result of gravel hauling is considered to be negligible.

The length of the ice season and timing of freezeup and breakup could have an impact on ice road hauling activities and result in delays to construction. It is anticipated, however, that impact on the project would be minimized through ice thickness monitoring.

Trucks and heavy equipment can weigh down floating ice and cause vertical movement which is potentially hazardous to personnel and equipment, particularly if much of the weight is concentrated in one area. This could be an issue during on-ice construction activities such as trenching and gravel hauling. Thickening of the ice for road use in construction, and spacing and weight limitations on heavy vehicles, would result in negligible vertical ice movement, no impact to the floating fast ice, and no impact to the project schedule.

Storm surges can lift grounded landfast ice in the lagoon area and cause flooding over the surface of the ice and the ice road. Nuiqsut whaling captains spoke of sea ice breaking around grounded ice floes during a rise in marine water level (F. Long, Jr. and T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:8). Equipment can still operate with water on the ice surface, and cracks are likely to freeze over and repair. Flooding of the ice surface would cause negligible, short-term impacts to hauling activities, would not affect the ice road's integrity, and would result in no impact to sea ice.

Onshore pipeline and landfall pad construction would have no impact on sea ice. For the Alternative 2 and 3 offshore pipeline segment between Point Storkersen and Seal Island, sea ice would be cut for winter trenching and pipe-laying activities. The width of the ice slot would be 5 ft (1.5 m), and on floating ice it would be up to 12 ft (3.7 m) wide (INTEC, 1996c:9). In addition, ice thickness would be increased for use as a road bed along the offshore pipeline alignment. Disturbances to sea ice would be limited to thickening and vertical movements. Disturbances would be short-term, limited to the immediate vicinity of the pipeline route, and would have a negligible impact on sea ice. Negligible similar impacts would be expected for Alternatives 4 and 5.

The length of the ice season and timing of breakup would have an important effect on the pipeline construction schedule. An early onset of breakup, or complete loss of ice cover during what would normally be considered the ice season, could extend the duration of pipeline installation (INTEC, 1996c:17). Nuiqsut residents have reported on the hazards of open leads in the project area, particularly during the spring (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996). Impacts to the project from ice season length or leads would be negligible and would be minimized through ice thickness monitoring, and contingency planning.

Vertical ice movement during construction activities described previously for gravel hauling activities also could influence pipeline construction. As a result of thickening of the ice for road use in gravel hauling, and spacing and weight limitations on heavy vehicles, the effects of vertical ice movement would be considered a negligible impact.

Large horizontal sea ice movements over a short period of time could move the ice slot with respect to the trench. Large but rare ice movements have been described in the project area. In mid-March 1981, storm winds caused the ice less than a mile west of Seal Island to separate, opening a 120-ft (36.6 m) wide lead in the ice. However, based on field measurements in the project area over the course of four winters, such movements are rare. The median total ice movement rate near Seal Island is less than 1-ft/day (0.3 m/day) (Agerton, 1982: 2.1). Maximum total horizontal ice movement in the project area is 6.6 ft/day (2 m/day) (Section 5.6.1.3). Typically, horizontal ice movement is characterized by a back and forth motion, thus ice movement is expressed as total movement, not total movement in a single direction. A 1979 ice movement study found that a considerable amount of tide-driven oscillatory, or back and forth, movement did occur in the ice sheet and resulted in negligible net displacement of the ice (OSI, 1980a:5; 1980b:Table 2; 1980c:3).

Daily net horizontal movements of less than 3 ft (0.9 m) would not affect pipeline construction activities. Net movements of 3 to 6 ft/day (0.9 and 1.8 m/day) could require repositioning of the pipeline within the alignment, or repositioning of slotting and pipe-laying equipment. Net ice movements in this range also could result in backfill being misplaced over the pipeline trench, which could require remedial backfill dumping at a later date. Daily net ice movements greater than 6 ft (1.8 m) would likely require stopping construction activities until net movement slowed to a manageable rate.

Ice floe invasions could occur during the open water season. The presence of ice floes could cause delays in delivery of modules and other supplies, as well as the installation of the slope protection system. Floes striking the island slopes or marine outfall area before installation is complete could cause localized damage to gravel slopes or outfall piping, potentially causing delays in the construction schedule. These impacts would be negligible and minimized through short-term schedule changes, and minor repairs (if needed) during construction.

Offshore pipeline construction would include acoustic profiling, route surveying, and ice movement surveying conducted continuously during pipeline construction to monitor effects of horizontal ice movement, and allow changes to construction plans within a short time frame (INTEC, 1996c:18,19). In addition, a marine survey of the route would be conducted 1 year following construction and prior to start-up to confirm that the minimum design backfill is present (HLA, 1997:1).

Operation Impacts: The impacts of sea ice for Alternatives 2 and 3 during operations would be primarily related to damage to the island, facilities, or buried pipelines from ice hazards and effects on normal operations due to variations in ice seasons and floe movements.

An extreme override event on Seal Island could result in damage to the drilling rig, wellheads, or other equipment. Ice forces could also cause damage to the slope of the island. Ice pile-up would likely occur at the waterline around the perimeter of Seal Island following freezeup, creating an ice rubble collar around the island by late November. Based on the frequency distribution of data for Stump and Seal Islands and others in the project vicinity it was predicted that a maximum ice pile-up height of 56 ft (17 m) could occur as a 100-year event at Seal Island (INTEC 1996a:3-24). The effects of an extreme ice override event would be reduced through island design and monitoring of sea ice conditions. The design of Seal Island includes a 75-ft (23 m) wide bench and a 21- to 27-ft (6.5 to 8.3 m) high sheet pile wall to protect against ice override (CFC, 1996:5).

However, Nuiqsut whaling captains indicated that, based on observations of ice conditions and override events, the island height would need to be on the order of 30 to 50 ft (9 to 15 m), or equivalent in height to an offshore drilling platform, to withstand ice override hazards that are likely to occur (F. Long, Jr. and T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:10). In addition, it was suggested that the sheet pile wall have a concave shape to turn back overriding ice.

Based on the project design specifications, Seal Island would be constructed with a work surface elevation of approximately 16 ft (4.9 m) above sea level. As discussed previously, a perimeter sheet pile wall 21 to 27 ft (6.4 to 8.2 m) high and a 75-ft (23 m) wide bench would be constructed to divert ice during override events. Over the expected 15-year life of the production island and facilities, it is possible that ice could at some point overtop the perimeter wall and reach the island work surface. Engineering modeling and design indicate that the island and facilities are designed to withstand predicted ice override events with minor impacts. However, discussions with Nuiqsut whaling captains indicate that the height of the sheet pile may not be adequate for extreme override events (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:10).

Ice pile-up and ride-up at the Point Storkersen landfall are potential hazards to the normal operations of the pipeline. The likelihood of pile-up and ride-up occurring at the shoreline is low. Based on observations and aerial photo analyses, ice ride-up in the landfall area would be unlikely, since the barrier islands and shallow lagoon in this area provide protection against large ice movements (INTEC, 1997b:6). However, observations by whaling captains indicate that a southwest storm event accompanied by high water and floating ice can affect the area inside the barrier islands (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996). Ice ride-up in the landfall area of Alternative 5 would be unlikely, since the West Dock causeway provides protection against large ice movements. In addition, the proposed 110-ft (33.5 m) setback from the shoreline for the pipeline and facilities would minimize the risk from extreme events. It is unlikely that the ice pile-up would reach 110 ft (33.5 m) from the shoreline, thus the aboveground pipeline and valve station are not expected to be damaged by even an extreme pile-up event (INTEC, 1996a:Attachment: Drawings). Due to the coastal setback, an extreme pile-up would result in a minor impact to project landfall facilities.

Ice loading stresses from ice forces other than those that occur during an override event could affect island operations. Horizontal movement of first-year ice during fall and winter could form a rubble collar around the island; and multi-year ice floes could strike the island during the summer or freezeup season at relatively high speeds. The latter event is less likely to occur, but could have a more severe impact on the island slopes. The risk of ice pressures having an impact on the structural integrity of the island slopes would be minimized through design and annual maintenance. Because interlocking concrete mats would be used to protect the island from normal ice loading stresses, impacts to the island from normal ice movements are considered minor. Due to the proposed 110 ft (33.5 m) setback, it is unlikely that normal ice movements would affect onshore facilities and, therefore, no impact is expected.

Ice thickness would be increased each winter for use as a road between the island and the mainland. As is the case during the construction phase, the construction and use of ice roads would result in a negligible impact to sea ice. Vertical or horizontal ice movement could impact operations activities; however, as previously discussed, impacts would be minimized through design of ice roads, spacing and weight limitations on heavy vehicles, and monitoring of ice conditions, and would be negligible.

Past testimony by Inupiat residents has demonstrated concern about the potential for an oil spill resulting from an ice gouge damaging or breaking a buried pipeline (I. Akootchook in USACE, 1984:16; F. Long, Jr. in USDOI, MMS, 1995:25; Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:3). Ice gouging would be a potential hazard to the normal operations of the buried offshore pipeline. Design for the offshore pipeline is based in part on ice keel protection analysis and specifies a minimum burial depth of 7 ft (2.1 m); north of the Barrier Islands, the pipeline will be buried at depths between 8 to 10 ft (2.4 to 3 m); (INTEC, 1997a:6). This depth would be 3.5 times greater than the depth of the deepest ice gouge observed in the vicinity of the proposed route, which was 2 ft (0.6 m). The design burial depth is twice as great as the predicted 100-year event gouge depth of approximately 3.5 ft (1.1 m) for the project area. Based on an analysis of ice gouge data, it was concluded that burial of the pipeline to a depth of 7 ft (2.1 m) would adequately limit pipeline damage from a 3.5-ft (1.1 m) deep gouge (INTEC, 1997a:4).

Project plans also specify that additional wall thickness (over standard) pipe be used in all sections of the submarine pipeline. Extra thick pipe is intended to protect the pipeline from overburden pressure of an ice keel gouging the sediment above the pipeline. Pipeline integrity would be monitored regularly. Studies have shown that the deepest and potentially most damaging gouges have occurred in deep water. Portions of the pipeline routes located in deep water are 1.8 miles (2.9 km) for Alternatives 2, 3, 4, and 5. Consequently, all alternatives are approximately equal in terms of susceptibility to damage from ice keels. Should an ice keel contact the pipeline, it is likely that the combination of burial depth and pipe thickness would prevent more than a minor impact to the pipeline's integrity.

Erosion of the seafloor and exposure of the pipeline from strudel scour is a potential hazard, especially in the 6- to 16-ft (2 to 4.9 m) water depth range (INTEC, 1997c:5, 11, 12). Approximately 4.1 miles (6.6 km) of pipeline is routed through depths of this range under Alternatives 2 and 3, approximately 7.2 miles (11.5 km) under Alternative 4, and approximately 7.1 miles (11.4 km) under Alternative 5. Surveys indicate a higher concentration of strudel holes along linear features such as tidal cracks and ice roads (Vaudrey, 1985a; 1986). Subbottom marine surveys of the pipeline route would be used to detect strudel scour locations which may pose a threat to the integrity of the pipeline. Exposure of the pipeline by strudel scour would not cause the pipeline to fail. Rather it would result in a maintenance situation where a repair, backfilling of the scour, would be carried out to correct the problem. For this reason, impacts to the pipeline as a result of strudel scour are considered to be minor. Strudel scour densities in the project area are shown on Figure 5.6-8.

Regular geometry pigging, which monitors the curvature of the pipeline's longitudinal axis (bending, such as sags or heaves, and ovality [roundness]), would be used to detect pipeline damage from ice gouging and strudel scour. Geometry pigging would be conducted at start-up, annually for the first 5 years, and every 2 years thereafter. Additional geometry pigging runs would be conducted if severe gouges or scours are observed/suspected to have occurred. As part of the pipeline inspection program, subbottom marine surveying would also be conducted to evaluate backfill thickness and the presence of ice gouges. These surveys would be conducted 1 year after construction, and every 5 years thereafter (or as required by permitting/regulatory agencies) (INTEC, 1996b:5; HLA, 1997:1).

An oil spill during the operations phase could result in limited ice melt due to contact with warm oil or weakening due to encapsulation of spilled oil during new ice growth. Weakening of the floating ice sheet due to oil encapsulation could affect the integrity of the ice roads for a short period of time. Melting of the sea ice would be minimal since the heat from the oil being released would quickly be lost in the surrounding marine waters and ice. The impact from weakening of the sea ice is considered short-term and minor since the duration would be limited to one ice season. Sea ice would have a direct effect on oil spill response and cleanup activities. The effects of broken sea ice in a large oil spill scenario is discussed in Chapter 8.

Maintenance Impacts: Maintenance activities associated with operation of the production island and pipeline would take place year-round over the expected 15-year life of the project. While damage to facilities from sea ice forces could make maintenance and repair necessary, the effects of ice on these activities would be limited. The timing of breakup and freezeup, the length of the ice season, and the occurrence of ice floe invasions during the open water season, would have effects on maintenance activities. Maintenance activities would have a negligible impact on sea ice.

Horizontal ice movements are likely to have similar effects on winter pipeline repair operations as those described for pipeline construction, although smaller in scope. Vertical deflection caused by storm surges, or the presence of heavy equipment may impact pipeline repairs or use of the ice road. The risk of such ice movements to the ice road or pipeline repair operations is low. The use of similar monitoring and surveying methods as those used during pipeline construction would be applied to minimize potential problems from ice. Impact from horizontal and vertical ice movement during pipeline maintenance is considered to be negligible.

Inupiat residents are concerned with how the pipeline would be accessed for repairs during the open water season in the presence of ice floes, and during winter through floating ice (Pers. Comm., Nuiqsut Community Meeting, August 14, 1996:2). Repairs would be conducted during summer using a repair barge or shallow draft vessel, and during winter using ice-based equipment in the same manner as that required for construction. Periods during which repairs could not be conducted include early winter when the ice is not strong or thick enough to support equipment, and during breakup when the potential for local ice failure is high and moving ice floes are not compatible with marine operations (INTEC, 1996b:9). If damage to the pipeline were to occur during these seasons that required immediate repair or indicated the potential for an oil spill, the pipeline would be shut down until stable ice or water conditions existed to allow repairs to be conducted safely. For these reasons, impacts from sea ice to pipeline repair activities are considered to be negligible.

Abandonment Impacts: The offshore segment of the pipeline would either be removed or abandoned in place. Removal of the pipeline would presumably be conducted similarly to the installation, and would involve winter trenching through sea ice. This impact to the sea ice would be short in duration and localized with only negligible impacts, and in place abandonment would have no impact to the sea ice.

5.6.3 Summary of Environmental Consequences

Development of the Northstar Unit would impact sea ice temporarily. With the exception of oil spill effects, which are discussed separately in Chapter 8, none of the impacts from sea ice would be significant. No significant unavoidable adverse effects from sea ice would result from construction and operation activities. All identified effects would be short-term, partly due to the limited duration of activities, and partly due to the seasonal presence of sea ice. The project would not require any irreversible or irretrievable commitment of resources with respect to the sea ice. Project components have been designed to anticipate, accommodate, and alleviate potential impacts from sea ice during all phases of the project.

Traditional Knowledge, however, indicates that design specifications may not be adequate to protect project facilities in the event of an extreme ice override at Seal Island. Maximum ice pile-up height of 56 ft (1.7 m) could occur as a 100-year event at Seal Island (INTEC, 1996a:3-24). Were such an event to occur and should the sheet pile protection be overridden by a large quantity of ice, project facilities on the island could be damaged. Likewise, an extreme ice pile-up at Dock Head 2 facilities, which are not protected by a 110-ft (33.5 m) setback, could also be damaged.

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TABLE 5.3-1
SEDIMENT CHARACTERISTICS FROM OFFSHORE BORINGS
IN THE PROJECT AREA

Approximate Age	Data Source	Number of Borings	Approx. Unit Thickness (feet)	Predominant Grain Size Classification[1]	Ice Bonded?	% Fines (Passing #200)
INSHORE OF BARRIER ISLANDS						
Holocene	Miller (1996)	12	13.5 - 27.5	SM/ML	Mixed	4.3 - 88.5
	McClelland (1985)	2	5 - 13	SP/SM	Mixed	--
	Benton (1970)	1	6.6 - 25.6	--	--	--
Pleistocene	Miller (1996)	5	34+	GP/SP-SM	Mixed	4 - 6.7
	McClelland (1985)	2	31.5+	SP	Mixed	--
	Benton (1970)	1	33.4+	--	--	--
BARRIER ISLANDS (Approximately 1,000 Feet Offshore)						
Holocene	Miller (1996)	7	24 - 42.5	SM/SP/ML	Yes	4.8 - 84.6
	McClelland (1985)	11	11 - 34	SP-SM/ML	Mixed	--
	Benton (1970)	1	30	--	--	--
Pleistocene	Miller (1996)	2	31+	GP/SP	Mixed	0.8
	McClelland (1985)	11	24+	GP/SP	Mixed	--
OFFSHORE OF BARRIER ISLANDS						
Holocene	Miller (1996)	10	15 - 30.5	SP/SM/ML	No	1.4 - 8.7
	McClelland (1985)	3	8.5 - 17	--	No	--
	Woodward-Clyde Consultants (1981)	9	3.5 - 23	SM/SP	No	--
	Benton (1970)	2	6.6 - 9.2	--	--	--
Pleistocene	Miller (1996)	4	72+	GP	No	0.1 - 7.6
	McClelland (1985)	3	26.5+	--	No	--
	Woodward-Clyde Consultants (1981)	8	59+	GP	No	--

Note: Location of borings shown on Figure 5.3-6.
-- = Not analyzed or not applicable
1 = ASTM, 1995:207-217
Benton = Benton Engineering as cited in Miller, 1995:2-5
Miller = Miller, 1996:Pl.B1-B19
McClelland = McClelland-EBA, Inc., 1985:Pl.3-19
Pleistocene = More than 11,000 years before present
Woodward-Clyde Consultants = WCC, 1981:Figs. 3-7
% = Percent
SM = Silty sand
ML = Silt
GP = Poorly graded gravel
SP = Poorly graded sand
Holocene = Less than 11,000 years before present

Source: This was compiled and prepared by Dames & Moore using listed references.

TABLE 5.3-2
MARINE SEDIMENT CHEMISTRY RESULTS IN THE PROJECT AREA

Sample No.	DRO (EPA 8100M) (mg/kg)	VOCs (EPA 8260A)		SVOCs (EPA 8270)		TCLP Barium (EPA 1311.6010) (mg/L)	Soluble Barium[3] at pH 5 by TCLP (mg/L)	Metals (EPA 6010; Mercury 7471)					
		Methylene chloride (mg/kg)	Toluene (mg/kg)	Bis (2-ethylhexyl) phthalate (mg/kg)	Di-n-butyl phthalate (mg/kg)			Barium (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)
95NS-S001	ND(16)	22 B	ND(1.7)	0.93	ND(0.29)	--	--	90	ND(0.46)	18	11	ND(0.16)	77
95NS-S003	ND(10)	NA	NA	ND(0.18)	ND(0.18)	--	--	9.6	ND(0.27)	0.6	2	0.14	4.3
95NS-S005	ND(12)	12 B	ND(1.2)	ND(0.21)	0.18 J	--	--	71	ND(0.31)	6.5	2.9	ND(0.12)	30
95NS-S006	ND(15)	11 B	ND(1.5)	0.20 J	0.21 J	--	--	160	ND(0.38)	17	12	ND(0.15)	63
95NS-S013	ND(16)	17 B	2.4	ND(0.29)	ND(0.29)	--	--	93	ND(0.46)	17	8.5	ND(0.17)	64
95NS-S018	ND(15)	17 B	ND(1.7)	ND(0.28)	ND(0.28)	--	--	86	ND(2.2)	18	9.2	ND(0.16)	73
95NS-S019 [1]	ND(16)	30 B	ND(1.7)	ND(0.29)	ND(0.29)	--	--	91	ND(2.1)	20	12	ND(0.17)	85
95NS-S023	ND(13)	4 J,B	ND(1.3)	0.16 J	ND(0.21)	--	--	74	ND(0.66)	4.5	2.7	ND(0.13)	21
95NS-S024	ND(13)	3 J,B	ND(1.3)	0.69	ND(0.22)	--	--	110	ND(1.7)	8.2	4.6	ND(0.13)	35
95NS-S025	ND(12)	ND(6.8)	ND(1.4)	ND(0.23)	ND(0.23)	--	--	62	ND(0.71)	5.5	3.2	ND(0.14)	25
95NS-S029	ND(14)	4.1 J,B	ND(1.4)	ND(0.23)	ND(0.23)	--	--	48	ND(0.69)	8.6	4.6	ND(0.13)	32
95NS-S034	ND(16)	7.1 J,B	6.1 J	ND(0.27)	ND(0.27)	0.26	5.2	99	ND(2.2)	15	6.6	ND(0.16)	57
95NS-S035	ND(14)	9.1 B	ND(1.6)	ND(0.27)	ND(0.27)	0.19	3.8	59	ND(0.83)	13	5.5	ND(0.16)	47
95NS-S036 [2]	ND(14)	13 B	ND(1.6)	ND(0.27)	ND(0.27)	0.20	4.0	74	ND(0.80)	14	5.8	ND(0.15)	54
95NS-S037	ND(13)	13 B	ND(1.2)	ND(0.20)	ND(0.20)	0.15	3.0	20	ND(0.66)	4.7	ND(2.0)	ND(0.11)	19
95NS-S038	ND(12)	14 B	7	ND(0.19)	ND(0.19)	0.23	4.6	37	ND(0.59)	3.8	2.6	ND(0.11)	21

Notes:
- -- = Not applicable
- 1 = Sample No. 95NS-S019 is a field duplicate of 95NS-S018.
- 2 = Sample No. 95NS-S036 is a field duplicate of 95NS-S035.
- 3 = Soluble barium is determined to be 20 times greater than the TCLP Barium value due to a dilution in the TCLP method.
- B = Analyte is found in the associated blank as well as the sample.
- J = Estimated value (Measured concentration below the estimated limit but above the method detection limit)
- DRO = Diesel range organics
- EPA = U.S. Environmental Protection Agency
- mg/kg = Milligrams per kilogram
- mg/L = Milligrams per liter
- NA = Not analyzed due to physical characteristics of matrix (rocks)
- ND( ) = Not detected (reporting limit)
- SVOCs = Semi-volatile organic compounds
- TCLP = Toxicity Characteristic Leaching Procedure
- VOCs = Volatile organic compounds

Source: WCC, 1996:Table 3

TABLE 5.3-3
FLOW DATA FOR THE KUPARUK AND PUTULIGAYUK RIVERS

River	Distance from Mouth (miles)	Approx. Years of Record	October				November				December				January			
			Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)
Kuparuk	10	1971-1996	10	692	212	∀ 167	0	174	19	∀ 36	0	24	3	∀ 6	0	10	2	∀ 3
Putuligayuk	7.3	1970-1986	0	15	2	∀ 4	0	0	0	∀ 0	0	0	0	∀ 0	0	0	0	∀ 0

River	Distance from Mouth (miles)	Approx. years of Record	February				March				April				May			
			Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)
Kuparuk	10	1971-1996	0	10	2	∀ 3	0	10	2	∀ 3	0	10	2	∀ 3	0	6,572	1,098	∀ 1,624
Putuligayuk	7.3	1970-1986	0	0	0	∀ 0	0	0	0	∀ 0	0	0	0	∀ 0	0	54	4	∀ 14

River	Distance from Mouth (miles)	Approx. years of Record	June				July				August				September			
			Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)	Range[1] Min. (cfs)	Range[1] Max. (cfs)	Average[2] (cfs)	STD[3] (cfs)
Kuparuk	10	1971-1996	726	26,360	11,056	∀ 5,459	310	2,439	977	∀ 593	127	5,095	1,526	∀ 1,400	193	3,607	1,368	∀ 1,005
Putuligayuk	7.3	1970-1986	163	694	451	∀ 158	3	64	21	∀ 17	0.1	49	9	∀ 13	0.4	62	15	∀ 20

Notes:
1 = Range of monthly means for period of record
2 = Average of monthly means for period of record
3 = Standard Deviation
cfs = Cubic feet per second
Max. = Maximum
Min. = Minimum

Sources: Kuparuk River: USDOI, GS, 1996
Putuligayuk River: USDOI, GS, 1970; 1971; 1972; 1973; 1974; 1975; 1976; 1977; 1978; 1979; 1982; 1983; 1984; 1985; 1986.

TABLE 5.3-4
RANGE OF WATER QUALITY CONSTITUENTS, KUPARUK AND PUTULIGAYUK RIVERS

Chemical Constituent	Kuparuk River						Putuligayuk River					
	Minimum Concentration			Maximum Concentration			Minimum Concentration			Maximum Concentration		
	Concentration	Date	Discharge (cfs)	Concentration	Date	Discharge (cfs)	Concentration	Date	Discharge (cfs)	Concentration	Date	Discharge (cfs)
Turbidity (NTU/JCU)	0.00	6/19/77	308	33	6/11/86	29,400	1	6/23/72	200	20	7/18/74	12
pH	6.3	8/7/84	6,580	8.2	11/20/70	N/A	7.4	6/9/70	1,220	8.3	9/5/70	0.6
Dissolved Oxygen (mg/L)	1.4	4/29/75	N/A	14.6	6/9/75	748	11.0	9/5/70	0.6	14.9	10/15/71	N/A
Phosphate[1] (mg/L)	0.00	3/18/72	N/A	0.18	9/18/83	2,620	0.0	Multiple Years	N/A	0.31	6/14/75	1,870
Nitrogen[2] (mg/L)	0.05	6/25/77	7,300	0.92	6/7/80	35,700	0.20	6/23/72	200	0.91	9/20/75	6.3
Nitrate[3] (mg/L)	0.00	8/13/71	654	0.42	2/6/76	0.00	0.00	8.00	2.00	0.66	6.00	157.00
Nitrite[3] (mg/L)	ND	Multiple Years	N/A	0.01	6/16/81	5,720	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
1 = Phosphate reported as orthophosphate, dissolved
2 = Nitrogen reported as total organic
3 = Reported as dissolved
cfs = Cubic feet/second
NTU = Nephelometric Turbidity Unit, for Kuparuk data
JCU = Jackson Candle Unit, for Putuligayuk data
mg/L = Milligrams per liter
N/A = Not applicable or not available
ND = Not detected

Sources: Kuparuk River: USDOI, GS, 1996
Putuligayuk River: USDOI, GS, 1970; 1971; 1972; 1973; 1974; 1975; 1976; 1977; 1978; 1979; 1982; 1983; 1984; 1985; 1986.

TABLE 5.3-5
SEDIMENT DISCHARGE DATA,
KUPARUK AND PUTULIGAYUK RIVERS

River	Number of Measurements	Period of Record	Suspended Sediment Discharge (Tons/Day)			
			Minimum	Maximum	Average	Standard Deviation
Kuparuk	61	1971-1986	0.00	55,600	2,951	± 9,027
Putuligayuk	13	1970-1976	0.04	825	115	± 229

Source: USDOI, GS, 1996:Table 1

TABLE 5.3-6
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON GEOLOGY AND HYDROLOGY

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	Freshwater required for ice roads ranges from 13 to 14.9 million gal (49.2 to 56.4 million liters).	None - To soil or sediment would be expected. Minor - To lake water level and water quality which would total 15% of permitted usage from Kuparuk Deadarm mine site.	None anticipated.
Ice Roads - Operations	Annually	All winter	Freshwater required for ice roads is approximately 5.9 to 7.8 million gal (22.3 to 29.5 million liters) to connect West Dock to Seal Island.	None - To soil or sediment would be expected. Minor - To lake water which would total less than 15% of permitted usage from Kuparuk Deadarm mine site.	None anticipated.
Island – Construction	Once	3 Months	700,000 to 800,000 yds^3 (535,185 to 611,647 m^3) gravel moved and emplaced.	Negligible – To sediment from construction dewatering discharge. Minor – To sediment from direct covering and suspension and redeposition; to sediments due to plume from regrading island slope and berm before installation of concrete mat(s).	None anticipated.
Island – Operation/ Maintenance	Annually	15 years	Seal Island and immediate vicinity. Minor amounts of gravel moved. 23 wells would be drilled. Injection of 120 million barrels waste. Withdrawal of 158 million barrels oil.	Negligible - To sediment from island discharges or settling of suspended material; to geological environment and ground subsidence from removal of oil. Negligible to Minor - From drilling or injection of wastes, and island maintenance and repair. Minor - To subsurface geological environment and shallow sediment quality from injection of wastes; to island facilities from permafrost thaw settlement; to operations from potential shallow gas accumulations.	None anticipated.

TABLE 5.3-6 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON GEOLOGY AND HYDROLOGY

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline – Construction	Once	3 Months (Winter)	Lengths vary from 6 to 9 miles (9.7 to 14.5 km).	Negligible – To sediment chemical quality from trenching and pipeline covering activities. Minor - To sediment settling of suspended sediment along trench margins and spoils disposal; to sediment from West Dock causeway widening for Alternative 5.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Pipeline lengths vary from 6 to 9 miles (9.7 to 14.5 km). Repair scenarios would vary with season and magnitude of problem.	Negligible - To pipeline from extension of barrier islands by natural processes; to pipeline stability from vibration. Minor – Localized, to sediment if a repair were required; to subsea pipeline from permafrost settlement (possible exception: Alt. 5); to Alts. 2, 3, and 4 shore approach facilities from coastal erosion; to subsea pipeline from scour and storm channeling.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	Total lengths range from 11.9 to 15.6 miles (19.1 to 25.2 km). Lengths of undisturbed tundra crossing range from 3.1 to 9.6 miles (5 to 15.5 km).	Negligible - To surface water resources, including the Putuligayuk River. Minor - To soils along the pipeline route; onshore soils at the shore landing and valve pad.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Lengths vary from 11.9 to 15.6 miles (19.1 to 25.2 km).	None– To river hydrology. Negligible to Minor – To pipeline from coastal erosion. Negligible to Minor - To permafrost and surface water resources; to physical hydraulic processes; to onshore soil from inspection, operation, and maintenance activities.	None anticipated.

TABLE 5.3-6 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON GEOLOGY AND HYDROLOGY

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Gravel Mining	Once Occasionall y	3 Months (Winter) Unknown	35 acres (14 hectares) for Alternatives 2, 3, and 4. Additional gravel needed for Alternative 5 causeway widening.	Minor - To onshore geology and hydrology.	None anticipated.
Large Oil Spill	Rare	Unknown	Area contacted by oil - up to 200 miles (322 km) of coastline.	Significant - Contamination (sheens or free product) of soils, sediment, and surface water bodies from direct oiling and deposition of tarballs, potentially last for 5 to 10 years.	Minor - Thawing or disturbance of permafrost for the area (few hundred square yards) of vegetation damaged or removal during spill response.
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method.	Negligible to Minor - To soil from pipeline removal; sediment from island and pipeline removal.	Negligible to Minor – If pipelines remained in place.

Notes:
< = Less than
Alt. = Alternative
ft = Feet
gal = Gallons
km = Kilometer
m = Meters
m^3 = Cubic meters
yd^3 = Cubic yards

TABLE 5.4-10
AIR QUALITY IMPACTS FOR ON-ISLAND CONSTRUCTION ACTIVITIES

Pollutant	Averaging Period	Worst Case Year	NAAQS ($\mu g/m^3$)	Maximum Concentration [a] ($\mu g/m^3$)	Background Concentration [b] ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)
CO	1-Hour	1991	40,000	1969.0	NA	1,969.0
	8-Hour	1988	10,000	580.2	NA	580.2
NO_2 [c]	Annual	1987	100	90.2	7.0	97.2
PM_{10}	24-Hour	1989	150	121.2	6.3	127.5
	Annual	1987	50	10.8	0.1	10.9
SO_2	3-Hour	1988	1,300	157.0	3.8	160.8
	24-Hour	1989	365	71.0	3.8	74.8
	Annual	1987	80	5.2	0.1	5.3

Note:
- a = Highest second highest concentration requested for the short-term averaging periods, except for construction PM_{10} impacts (highest-sixth-highest). There is no 1.6 kilometer exclusion zone and impacts are considered at island edge.
- b = Background concentrations include global background values (SECOR, 1995a:Table 3-4); NO_2 background also includes inventory modeling results from nearby point sources. (See location and sources in Table 5.4-6.)
- c = Concentration adjusted using the Ozone Limiting Method (Wilson, 1997:1 and 2 - Copy provided in Appendix D).
- CO = Carbon monoxide
- $\mu g/m^3$ = Micrograms per cubic meter
- NA = Not available
- NAAQS = National Ambient Air Quality Standards
- NO_2 = Nitrogen dioxide
- PM_{10} = Particulate matter less than 10 microns in diameter
- SO_2 = Sulfur dioxide

Source: RILLC, 1998:Table 5-4

TABLE 5.4-11
PROPOSED BACT CONTROLS - DRILLING AND OPERATION ACTIVITIES

Pollutant	Sources	Proposed Control Technology
NO_X	Turbines	Dry Low NO_X
	Boilers/Heaters	Good Operating Practices
	Internal Combustion Engines (natural gas fueled)	Low Emission Combustion
	Internal Combustion Engines (diesel) - Cummins	Fuel Injection Timing Retard
	Internal Combustion Engines (diesel)	Good Operating Practices
	Incinerator	Good Operating Practices
CO	Turbines	Good Operating Practices
	Boilers/Heaters	Good Operating Practices
	Internal Combustion Engines (natural gas fueled)	Catalytic Oxidation
	Internal Combustion Engines (diesel fueled)	Good Operating Practices
	Incinerator	Good Operating Practices
PM_{10}	Turbines (natural gas fuel)	Good Operating Practices
	Boilers	Good Operating Practices
	Internal Combustion Engines	Good Operating Practices
	Incinerator	Good Operating Practices
	Flares	Smokeless Tip Design
VOCs	Turbines	Good Operating Practices
	Boilers/Heaters	Good Operating Practices
	Internal Combustion Engines (natural gas fueled)	Catalytic Oxidation
	Internal Combustion Engines (diesel fueled)	Good Operating Practices
	Incinerator	Good Operating Practices
	Tanks	None
SO_2	Turbines	Low Sulfur Fuel
	Boilers/Heaters	Low Sulfur Fuel
	Internal Combustion Engines	Low Sulfur Fuel
	Incinerator	Low Sulfur Fuel

Notes:
BACT = Best Available Control Technology
CO = Carbon monoxide
NO_X = Oxides of nitrogen
PM_{10} = Particulate matter less than 10 microns in diameter
SO_2 = Sulfur dioxide
VOCs = Volatile organic compounds

Source: RILLC, 1998:Section 4.6.1

TABLE 5.4-12
SUMMARY OF POTENTIAL OFFSHORE AIR EMISSIONS FOR LONG-TERM DRILLING AND OPERATION ACTIVITIES

Source	Fuel	Number	Maximum Rating	Tons Per Year				
				CO	NO_X	PM_{10}	SO_2	VOCs
LM 2500 Turbines	Gas	2	32,715 hp each	155.58	255.44	31.54	19.34	21.02
Mars 90 Turbines	Gas	3	11,892 kw each	217.57	249.12	61.76	13.51	62.26
Glycol Reboiler	Gas	1	5 MMBtu/hr	0.50	2.38	0.29	0.20	0.13
Glycol Heaters	Gas	1	1.05 MMBtu/hr	0.10	0.50	0.06	0.04	0.03
	Diesel	1	1.05 MMBtu/hr	0.02	0.08	0.01	0.08	0.00
Space Heaters	Gas	4	2.685 MMBtu/hr (total)	0.27	1.28	0.16	0.11	0.08
HP Flare [a]	Gas	1	0.079 MMscfd	4.91	0.90	0.19	0.12	1.86
LP Flare [b]	Gas	1	0.454 MMscfd	3.58	0.66	0.14	0.08	1.35
Camp Generator Prime Mode [c]	Diesel	2	2,362 kW each	7.55	38.74	1.17	2.53	0.75
Standby Mode [d]	Diesel	2	2,717 kW each	9.62	43.73	1.18	2.83	0.85
Storage Tanks	NA	NA	NA	NA	NA	NA	NA	0.25
Fire Water Pump	Diesel	1	755 hp	0.11	0.85	0.01	0.04	0.02
Incinerator	Gas/Waste	1	1.6 MMBtu/hr and 100 lb/hr	6.95	1.30	5.59	0.82	0.41
Cold Start Unit	Diesel	1	314 hp	0.07	1.34	0.01	0.09	0.14
Rig Boilers	Gas	2	6.3 MMBtu/hr each	1.26	6.00	0.72	0.51	0.32
	Diesel	2	6.3 MMBtu/hr each	0.23	0.92	0.09	0.98	0.01
Heaters	Gas	3	7.7 MMBtu/hr total	1.12	5.33	0.64	0.45	0.29
	Diesel	3	7.7 MMBtu/hr total	0.21	0.82	0.08	0.87	0.01
Portable Equipment	Diesel	Various	Variable	12.06	55.73	4.03	3.94	4.30
Totals				421.71	665.12	107.67	46.54	94.08

Notes:
CO = Carbon monoxide
hp = Horsepower
kW = Kilowatts
lb/hr = Pounds per hour
MMBtu/hr = Million British thermal units per hour
MMscfd = Million standard cubic feet per day
NA = Not applicable
NO_X = Oxides of nitrogen
PM_{10} = Particulate matter less than 10 microns in Diameter
VOCs = Volatile organic compounds
a = HP flare handles primary separators and gas turbine fuel
b = LP flare handles blanketing and fuel gas system.
c = Prime mode assumes electrical power provided by turbines.
d = 4 hours per day of operation.

Source: RILLC, 1998:Appendix A; BPXA, 1998

SO_2 = Sulfur dioxide

TABLE 5.4-1
AVERAGE CLIMATIC CONDITIONS FOR BARROW, PRUDHOE BAY, AND BARTER ISLAND, ALASKA

Parameter (Dates)	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Barrow													
Monthly Average Temp (°F)	-14.7	-18.6	-15.2	-0.9	19.1	33.0	38.7	37.6	30.3	15.3	-0.5	-12.3	9.3
Mean Wind Dir (1951-1963)	ESE	E	ENE	NE	E	ENE	E	E	E	E	E	E	NA
Mean Wind Speed (mph) (1951-1963)	11.3	10.9	11.2	11.5	11.6	11.4	11.5	12.4	13.1	13.3	12.6	11.2	11.8
Precipitation (inches) (1951-1980)	0.21	0.17	0.17	0.21	0.16	0.37	0.86	0.98	0.59	0.55	0.30	0.18	0.40
Prudhoe Bay (Deadhorse Airport)													
Hourly Mean Temp (°F)[1] (1996)	-16.6	-16.1	-11.4	1.3	23.3	36.6	46.4	43.1	31.6	16.0	-8.7	-13.7	11.0
Mean Wind Dir[2] (1969-1988)	ENE	WSW	WSW	ENE	ENE	E	ENE	ENE	ENE	ENE	ENE	WSW	NA
Mean Wind Speed[3] (mph) (1969-1988)	14.7	13.7	13.3	12.4	13.7	13.3	12.9	11.9	13.1	13.6	13.8	13.2	13.3
Precipitation (inches) (1983-1993)	0.55	0.35	0.47	0.44	0.55	0.46	0.66	1.07	0.72	0.75	0.50	0.51	0.59
Barter Island													
Monthly Average Temp (°F) (1951-1980)	-15	-20.5	-16.3	-0.9	20.9	34	40	39.9	31.4	15.2	0	-13	9.6
Mean Wind Direction	W	W	W	W	E	ENE	ENE	E	E	E	E	E	NA
Mean Wind Speed (mph)	13	12	12	10	11	10	10	11	12	13	14	13	11.8
Precipitation (inches) (1951-1980)	0.50	0.27	0.24	0.22	0.35	0.56	1.03	1.08	0.80	0.81	0.40	0.23	0.54

Notes:
1 = Monthly Average temperature from Well Pad A, Prudhoe Bay
2 = Mean wind direction taken at Deadhorse Airport (SECOR, 1995b:5)
3 = Mean wind speed taken at Deadhorse Airport (SECOR, 1995b:5)
°F = Degrees Fahrenheit
mph = Miles per hour
NA = Not applicable

N = North
S = South
E = East
W = West

Sources: USDOI, NOAA and Ruffner, 1985:20-29; GRI, 1992:25-28; SECOR, 1995a:Table 2-1, Figures 2-1 through 2-5; SECOR, 1995b:5; BPXA, 1996:4-2.

TABLE 5.4-13
COMPARISON OF DRILLING AND OPERATION PHASE MODELING ANALYSIS RESULTS TO NAAQS

Pollutant	Averaging Period	Worst Case Year[a]	NAAQS ($\mu g/m^3$)	Maximum Concentration[b] ($\mu g/m^3$)	Background Concentration[c] ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)
NO_2	Annual	1988	100	22.8[d]	7.8	30.6
PM_{10}	24-Hour	1989	150	21.6	7.0	28.6
	Annual	1988	50	4.5	0.1	4.6
SO_2	3-Hour	1988	1,300	179.1	6.8	185.9
	24-Hour	1988	365	85.6	4.8	90.4
	Annual	1988	80	4.2	0.1	4.3
CO	1-Hour	1991	40,000	213.7	NA	213.7
	8-Hour	1988	10,000	105.3	NA	105.3

Notes:
a = Year of meteorological data which produced highest air quality impacts.
b = Highest second highest concentration reported for the short-term averaging periods.
c = Background concentrations from SECOR (1995a:Table 3-4) NO_2 background includes existing sources in area.
d = Value adjusted using the Ambient Radio Method
CO = Carbon monoxide
NA = Not available
NAAQS = National Ambient Air Quality Standards
NO_2 = Nitrogen dioxide
PM_{10} = Particulate matter less than 10 microns diameter
SO_2 = Sulfur dioxide
$\mu g/m^3$ = Micrograms per cubic meter

Source: RILLC, 1998:Table 5
BPXA, 1998:Attachment E

TABLE 5.4-14
NORTHSTAR PROJECT DRILLING AND OPERATION
PSD CLASS II INCREMENT ANALYSIS

Pollutant	Averaging Period	Worst Case Year [a]	PSD Class II Increments Level ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)
NO_2	Annual	1988	25	24.7
PM_{10}	24-Hour	1989	30	21.6
	Annual	1988	17	4.5
SO_2	3-Hour	1988	512	179.1
	24-Hour	1988	91	85.6
	Annual	1988	20	4.2

Notes:
a = Year of meteorological data which produced highest air quality impacts.
b = Value adjusted using the Ambient Ratio Method. These impacts include NO_2 PSD Class II increment consumption from other PSD sources in the project area (see Table 5.4-6), as well as the proposed project.
NO_2 = Nitrogen dioxide
PSD = Prevention of Significant Deterioration
PM_{10} = Particulate matter less than 10 microns
SO_2 = Sulfur dioxide
$\mu g/m^3$ = Micrograms per cubic meter

Source: RILLC, 1998:Table 5-3
BPXA, 1988:Attachment D

TABLE 5.4-15
NORTHSTAR PROJECT DRILLING AND OPERATION PSD CLASS II INCREMENT ANALYSIS FOR ANWR, KAKTOVIK, AND NUIQSUT

Pollutant	Averaging Period	PSD Class II Increment Level ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$) [a]		
			ANWR	Kaktovik	Nuiqsut
NO_2	Annual	25	0.02	0.01	0.06
PM_{10}	24-Hour	30	0.07	0.03	0.14
	Annual	17	0.002	0.001	0.01
SO_2	3-Hour	512	0.35	0.21	0.38
	24-Hour	91	0.04	0.02	0.09
	Annual	20	0.001	0.001	0.004

Notes:
a = Highest second-highest concentration reported for the short-term averaging periods.
ANWR = Arctic National Wildlife Refuge
NO_2 = Nitrogen dioxide
PSD = Prevention of Significant Deterioration
PM_{10} = Particulate matter less than 10 microns
SO_2 = Sulfur dioxide
$\mu g/m^3$ = Micrograms per cubic meter

Source: RILLC, 1998:Table 5-5

TABLE 5.4-16
AIR EMISSIONS INVENTORY FOR THREE ONSHORE PROCESS FACILITIES

Source	Tons Per Year				
	CO	NO_2	PM_{10}	SO_2	VOCs
Shore Crossing					
Thermoelectric Generator	0.01	0.03	0.04	0.03	0.02
Central Compressor Plant Tie-In					
Compressor	25.67	35.43	8.21	1.91	7.35
Generator	9.44	8.81	1.01	0.22	1.26
Total	35.11	44.24	9.22	2.13	8.61
Pump Station No. 1					
Indirect-Fired Heater	2.34	11.15	1.34	9.40	0.59
Space Heater	0.11	0.51	0.06	0.43	0.03
Total	2.45	11.66	1.40	9.83	0.62

Note: CO = Carbon monoxide
NO_2 = Nitrogen dioxide
PM_{10} = Particulate matter less than 10 microns diameter
SO_2 = Sulfur dioxide
VOCs = Volatile organic compounds

Sources: BPXA:1998:Table A-1
RILLC: 1998: Appendix F

TABLE 5.4-2
NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Average Period	Primary Standard	Secondary Standard
CO	8 hour	9 ppm (10 mg/m^3)	Same as primary
	1 hour	35 ppm (40 mg/m^3)	Same as primary
SO_2	Annual arithmetic mean	0.03 ppm (80 $\mu g/m^3$)	Same as primary
	24 hour maximum	0.14 ppm (365 $\mu g/m^3$)	Same as primary
	3 hour maximum	no standard	0.5 ppm (1,300 $\mu g/m^3$)
PM_{10}	24 hour average	150 $\mu g/m^3$	Same as primary
	Annual arithmetic mean	50 $\mu g/m^3$	Same as primary
$PM_{2.5}$	24 hour average	65 ($\mu g/m^3$)	Same as primary
	Annual arithmetic mean	15 ($\mu g/m^3$)	Same as primary
NO_X	Annual arithmetic mean	0.053 ppm (100 $\mu g/m^3$)	Same as primary
Ozone	1 hour maximum	0.12 ppm (235 $\mu g/m^3$)	Same as primary
	8 hour maximum	0.08 ppm (157 $\mu g/m^3$)	Same as primary
Lead	Quarterly maximum arithmetic mean	1.5 $\mu g/m^3$	Same as primary

Note: CO = Carbon monoxide
SO_2 = Sulfur dioxide
PM_{10} = Particulate matter greater than 10 microns diameter
$PM_{2.5}$ = Particulate matter greater than 2.5 microns diameter
NO_X = Oxides of nitrogen
mg/m^3 = Milligrams per cubic meter
$\mu g/m^3$ = Micrograms per cubic meter
ppm = Parts per million

Source: 40 CFR, Part 50.1 through 50.9

TABLE 5.4-3
PSD SIGNIFICANCE LEVELS

Air Pollutant	Significant Emission Rate (tpy)
Criteria Pollutants:	
Carbon Monoxide	100
Nitrogen Oxides	40
Ozone (VOC)	40
Sulfur Dioxide	40
Particulate Matter less than 10microns	15
Total Particulate Matter	25
Hazardous Air Pollutants:	
Asbestos	0.007
Beryllium	0.0004
Fluoride [a]	3
Hydrogen Sulfide	10
Lead	0.6
Mercury	0.1
Vinyl Chloride	1.0
Other Air Pollutants:	
Sulfuric Acid Mist	7
Reduced Sulfur Compounds [b]	10
Total Reduced Sulfur [b]	10

Notes:
a = As hydrogen fluoride
b = Includes hydrogen sulfide emissions
PSD = Prevention of Significant Deterioration
tpy = Tons per year
VOC = Volatile organic compounds

Source: 40 CFR Part 52.21(b)(23)(i)

TABLE 5.4-4
PSD CLASS I AND II INCREMENTS

Pollutant/Averaging Period	Class I Increment ($\mu g/m^3$)	Class II Increment ($\mu g/m^3$)
NO_2		
Annual Mean	2.5	25
SO_2		
Annual Mean	2	20
24-Hour Maximum	5	91
3-Hour Maximum	25	512
PM_{10}		
Annual Mean	4	17
24-Hour Maximum	8	30

Notes:
NO_2 = Oxides of nitrogen
PM_{10} = Particulate matter greater than 10 microns diameter
PSD = Prevention of Significant Deterioration
SO_2 = Sulfur dioxide
$\mu g/m^3$ = Micrograms per cubic meter

Source: 40 CFR Part 52.21(c)

TABLE 5.4-5
SUMMARY OF NORTH SLOPE OIL FIELD AIR MONITORING PROGRAMS, 1990 - 1996

Facility	Year	Criteria in Micrograms per Cubic Meter					
		NO_2 Annual Mean	O_3 Max. 1-hour	SO_2			PM_{10} Maximum 24-hour Measurement
				Max. 3-hour	Max. 24-hour	Annual Mean	
Kuparuk Sites							
CPF-1	1990/91	16.0	90.2	44.5	26.2	4.4	--
	1991/92	13.2	115.6	28.8	15.7	5.2	--
DS1F	1990/92	4.9	92.1	55.0	13.1	2.6	--
	1991/92	3.8	100.0	13.1	5.2	2.6	--
Prudhoe Bay Sites							
CCP	1992/93	18.6	94.1	13.1	10.5	2.6	16.5
	1993/94	16.2	111.7	10.5	7.9	2.6	29.3
	1994/95	17.7	82.3	13.1	10.5	2.6	28.4
	1995/96	26.3	115.8	13.1	10.5	2.6	11.6
WPA	1992/93	9.4	152.9	--	--	--	--
	1993/94	11.9	180.3	--	--	--	--
	1994/95	8.1	103.9	--	--	--	--
	1995/96	9.4	106.0	--	--	--	--
GC1	1992/93	15.5	98.0	34.1	13.1	3.5	155.0
	1993/94	20.2	105.8	101.4	39.0	2.6	54.7
	1994/95	16.0	80.4	21.0	7.9	2.6	64.3
	1995/96	18.8	94.2	44.5	15.7	2.6	--
Current (1997) State of Alaska or NAAQS Standards		**100**	**235**	**1,300**	**365**	**80**	**150**

Notes:
-- = No data collected
CCP = Central Compressor Plant
CPF-1 = Central Processing Facility, Location 1
DS1F = Drill Site 1F
GC1 = Gathering Center 1
Max. = Maximum
NAAQS = National Ambient Air Quality Standards
NO_2 = Nitrogen dioxide
O_3 = Ozone
PM_{10} = Particulate matter greater than 10 microns in diameter
SO_2 = Sulfur dioxide
WPA = Well Pad A

Source: ENSR, 1996:ii

TABLE 5.4-6
TOTAL ALLOWABLE EMISSION RATES FOR ONSHORE OPERATING SOURCES (KUPARUK, PRUDHOE BAY, AND ENDICOTT)

Unit Name	Tons Per Year (Grams Per Second)			
	NO_2	**SO_2**	**CO**	**PM_{10}**
Prudhoe Bay	59,448 (1,710.1)	720 (20.7)	10,300 (296.3)	827 (23.8)
Kuparuk	7,763 (223.3)	643 (18.5)	1,846 (53.1)	393 (11.3)
Endicott (Duck Island)	3,202 (92.1)	24 (0.7)	674 (19.4)	28 (0.8)
Total	**70,413 (2,025.5)**	**1387 (39.9)**	**12,820 (368.8)**	**1,248 (35.9)**

Notes: Milne Point sources are not included. (NO_2 = 30.1 g/sec, SO_2 = 3.2 g/sec, CO = 12.4 g/sec, and PM_{10} = 1.7 g/sec)

The Lisburne and Deadhorse Power Plant allowable emission rates were included in the modeling of impacts for the Northstar Unit Development. Milne Point, Badami, and Pump Station No. 1 sources were not included in the modeling analysis.

CO = Carbon monoxide
g/sec = Grams per second
NO_2 = Nitrogen dioxide
PM_{10} = Particulate matter greater than 10 microns in diameter
SO_2 = Sulfur dioxide

Source: SECOR, 1995a:3-4

TABLE 5.4-7
ACTUAL EMISSIONS FROM BPXA AND ARCO OPERATED FACILITIES [1]
July 1, 1994 - June 30, 1995

Emission	BPXA Operations						ARCO Operations								
	PBU Western Operating Area[2]				Milne[2]	Endicott[2]	PBU Eastern Operating Area[2]								Lisburne[2]
	GC1	GC2	GC3	CPS			CCP	CGF	FS1	FS2	FS3	SIP (east)	STP	COTU	LPC
NO_X	5,905	2,875	2,314	5,515	1,046	2,986	12,528	9,611	2,490	2,693	3,729	1,912	450	23	2,350
CO	1,179	610	491	1165	285	856	1,307	2,116	1,426	842	810	369	101	3	701
SO_X	57	51.5	45	91	21	183	132	531	153	27	18	60	79	0.1	22
PM_{10}	150	75.2	61	150	28	96	4,708	271	72	422	36	24	16	1	89
VOCs	237	128.5	102	184	55	30	501	456	290	237	262	19	21	9	116

Notes:
1 = As reported to the Alaska Department of Environmental Conservation; provides actual emissions data based on stock measurements and/or actual throughputs, fuel use, etc.
2 = Units are in short tons (2,000 pounds) per year
ARCO = ARCO Alaska, Inc.
BPXA = BP Exploration (Alaska) Inc.
CCP = Central Compressor Plant
CGF = Central Gas Facility
CO = Carbon monoxide
COTU = Crude Oil Topping Unit
CPS = Central Power Station
FS1 = Flow Station 1
FS2 = Flow Station 2
FS3 = Flow Station 3
GC1 = Gathering Center 1
GC2 = Gathering Center 2
GC3 = Gathering Center 3
LPC = Lisburne Processing Center
NO_X = Oxides of nitrogen
PBU = Prudhoe Bay Unit
PM_{10} = Particulate matter greater than 10 microns in diameter
SIP = Seawater Injection Plant
SO_2 = Sulfur dioxide
STP = Seawater Treatment Plant
VOCs = Volatile organic compounds

Source: ARCO, 1994:3-6; BPXA, 1994:3

TABLE 5.4-8
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON AIR QUALITY

Action/Event	Frequency	Duration	Scope [1]	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	Along primary construction routes associated with each alternative.	Minor – Temporary and localized emissions from trucks and other mobile equipment.	None anticipated.
Ice Roads – Operations	Annually	All winter	Along primary construction routes associated with each alternative.	Minor – Temporary and localized emissions from trucks and other mobile equipment.	None anticipated.
Island – Construction	Once	3 Months	Along primary construction routes. Conventional equipment for concrete batch plant. Results of air quality modeling for on-island construction activities	Minor – Temporary and localized emissions from trucks and other mobile equipment, as well as fugitive dust. Minor – Temporary and localized emissions. Minor – Temporary and localized emissions from internal combustion engines and heaters, modeling results show compliance with NAAQS.	None anticipated.
Island – Operation/ Maintenance	Annually	15 years	Flare operating processing equipment, generators, boilers, storage tanks, drilling equipment, etc. at Seal Island.	Negligible - Temporary emissions from mobile equipment during maintenance, as well as fugitive dust. Minor – Long-term emissions of air pollutants associated with facility operations (including drilling) and support vehicles would occur, but would not result in the exceedance of any air quality standard. Modeling results show compliance with NAAQS; to ANWR, Kaktovik, and Nuiqsut from operations emissions; short-term, emergency release of air pollutants from flaring activities.	None anticipated.
Offshore Pipeline – Construction	Once	3 Months (Winter)	Along primary construction routes associated with each alternative.	Minor - Temporary and localized emissions from buses, trucks, other mobile, and some stationary sources.	None anticipated.

TABLE 5.4-8 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON AIR QUALITY

Action/Event	Frequency	Duration	Scope [1]	Direct Impacts	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Depends on maintenance or repair required. Along primary construction routes associated with each alternative.	Negligible - Temporary and localized short-term emissions from trucks, trenching equipment, and other mobile sources.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	Along primary construction routes associated with each alternative.	Minor - Temporary and localized emissions from buses, trucks, and other mobile sources.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Along primary construction routes associated with each alternative.	Negligible - Temporary and localized short-term emissions from bus trips and helicopter overflights; and pigging operations. Minor – Long-term emissions of air pollutants associated with sources at the shore-crossing, CCP tie-in location, and PS1.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionall y	3 Months (Winter) Unknown	Immediate vicinity of the gravel mine.	Minor - Temporary and localized emissions from trucks, mining equipment, other mobile sources, and fugitive dust.	None anticipated.
Large Oil Spill	Rare	Unknown	Air quality above the surface of the oil slick for first few days following the spill.	Minor - Release of volatile organic compounds to the air from the evaporation of 25% to 35% of the spilled oil.	Minor - Emission of criteria pollutants from machinery exhaust and/or in situ burning, temporarily reducing air quality for up to a few miles from the burn.
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method.	Negligible - Temporary and localized emissions from trucks and other mobile sources.	None anticipated.

Notes:
1 = Numbers do not include caribou crossings, infrastructure, process facilities, drilling, logistics, or island maintenance.
CCP = Central Compressor Plant
N/A = Not applicable
NAAQS = National Ambient Air Quality Standards
% = Percent
PS1 = Pump Station 1

TABLE 5.4-9
AIR EMISSIONS FOR ON-ISLAND CONSTRUCTION ACTIVITIES

Source	Fuel	Tons Per Year				
		CO	**NO_2**	**PM_{10}**	**SO_2**	**VOCs**
Non-Civil	Diesel	48.00	222.59	15.83	7.87	17.67
Civil	Diesel	97.23	450.00	32.20	15.73	35.33
Construction Reserve Pool	Diesel	13.22	60.90	4.42	2.07	4.65
Total		158.45	733.49	52.45	25.67	57.65

Note:
CO = Carbon monoxide
NO_2 = Nitrogen dioxide
PM_{10} = Particulate matter less than 10 microns in diameter
SO_2 = Sulfur dioxide
VOCs = Volatile organic compounds

Source: RILLC, 1998:Appendix A

TABLE 5.5-1
PREDICTED WAVES FOR POINT STORKERSEN SHORE

Wave Parameters	**Return Period - Years**				
	1	**10**	**20**	**50**	**100**
Westerly Storm					
Height (feet)	1	--	--	--	4.4
Period (seconds)	2	--	--	--	4.8
Easterly Storm					
Height (feet)	1	--	--	--	2.8
Period (seconds)	2	--	--	--	3.0

Note: -- = Not Available

Source: INTEC, 1996:3-39

TABLE 5.5-2
EXTREME WAVE PREDICTIONS AT SEAL ISLAND

Extreme Wave Prediction	**Return Period - Years**					
	1	**5**	**10**	**25**	**50**	**100**
Westerly Storm Events						
Height (feet)	7.1	8.3	10.8	14.6	18.4	19.9
Period (seconds)	6.8	7.8	8.3	5.1	9.9	10.9
Easterly Storm Events						
Height (feet)	7.6	8.3	9.7	11.1	11.8	12.8
Period (seconds)	7.0	7.5	7.8	9.9	10.7	12.3

Source: Offshore and Coastal Technologies, Inc. (1996) as cited in BPXA, 1997:Table 2.1-3

TABLE 5.5-3
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON OCEANOGRAPHY AND MARINE WATER QUALITY

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	Up to 200 ft (61 m) wide ice platform with thicknesses of up to approximately 8 ft (2.4 m); segments of road over sea ice constructed from West Dock to mouth of Kuparuk River and then to Seal Island.	None anticipated.	None anticipated.
Ice Roads - Operations	Annually	All winter	Similar route to construction ice road.	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Small island footprint increase from additional 700,000 to 800,000 yds^3 (535,191 to 611,647 m^3) of gravel; dewatering discharge of 1 to 2 million gallons (3.7 to 7.6 million liters) per day for 2 to 4 weeks adjacent to Seal Island.	Negligible – To bathymetry from slight island footprint increase including the addition of a 50- to 100-ft (15.2 to 30.5 m) wide gravel berm; to marine water quality from short-term increases in turbidity during gravel placement. Minor – To marine water quality from short-term elevated suspended sediment loading and turbidity from dewatering discharge and island grading.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Operational support vessel operations between Seal Island and the West Dock area; permitted discharges of continuous system flush, sanitary/domestic waste, desalination brine, and annual fire suppression test.	Negligible – To local oceanography from slight alteration of current direction and velocity due to the island; to marine water quality from support vessel operations, slope protection repairs, and permitted discharges. Minor – To marine water quality from berm replenishment activities.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	Length of offshore portion of pipeline varies by route: Alternatives 2 & 3 - 6 mi (9.6 km) Alternative 4 - 9 mi (14.5 km) Alternative 5 - 8.9 mi (14.3 km)	None - In nearshore bottomfast ice areas. Negligible – To marine water quality in offshore areas from short-term increases in suspended sediment and turbidity. Negligible to Minor – To marine water quality and bathymetry from release of excess spoil material.	None anticipated.

TABLE 5.5-3 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON OCEANOGRAPHY AND MARINE WATER QUALITY

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Length of offshore portion of pipeline varies by route: Alternatives 2 & 3 - 6 mi (9.6 km) Alternative 4 - 9 mi (14.5 km) Alternative 5 - 8.9 mi (14.3 km)	Minor – To offshore marine water quality from short-term, limited increases in suspended sediment and turbidity; to pipeline at West Dock scour.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None anticipated.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine waters contacted by oil - up to 200 miles (322 km) from the release site.	Minor – Dissolution and dispersion of hydrocarbons in water column (concentration depends on ice cover and time since release); State of Alaska water quality (chronic) criteria may be temporarily exceeded in close locale of spill plume.	Minor - Dissolution and dispersion of hydrocarbons contained in/on ice into the water column following spring breakup.
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method	Minor – To marine water quality from short-term increased suspended sediment and turbidity if pipeline and/or island slope protection is removed.	None anticipated.

Notes:
ft = Feet
km = Kilometers
m = Meters
m^3 = Cubic meters
mg/L = Milligrams per liter
mi = Miles
N/A = Not applicable
STP = Seawater Treatment Plant
yds^3 = Cubic yards

TABLE 5.6-1
ANNUAL ICE CYCLE IN NEARSHORE AREAS
OF THE ALASKAN BEAUFORT SEA

Timing	Event
Late September to early October	New ice begins to form in open water, forming first adjacent to rivers and in coastal lagoons.
Mid to late October	A continuous landfast ice sheet is formed. Ice outside of the bays and barrier islands is unstable.
November to February	The landfast ice area is extended from shore and is modified. Landfast ice becomes stable inside the 50 ft isobath by December. The general sequence of events includes: 1) a seaward progression of the ice edge, 2) ridging of successive ice edges, 3) incursions of older pack ice, and 4) grounding of ice masses either in situ or as they are driven ashore.
March to May	Ice is generally stable inside the 100-foot isobath, depending on location and time of year.
Late May to early June	River breakup results in flooding of nearshore ice.
Early June	Melt ponds begin to form on the ice; water ultimately drains through cracks and holes in the ice.
June	Ice begins to melt and weaken. Open water usually first occurs along the coast and around the barrier islands.
June to August	Breakup of the ice sheet continues.
August to September	Some open water is present nearshore in favorable years. Some thick older ice and ridge fragments may remain in the nearshore areas.

Source: Barnes et al., 1977

TABLE 5.6-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SEA ICE

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	Routes over sea ice from West Dock to mouth of Kuparuk River to Seal Island.	Negligible - to sea ice from ice thickening and from vertical ice movement due to vehicular traffic.	None anticipated.
Ice Roads - Operations	Annually	All winter	Routes over sea ice from West Dock to mouth of Kuparuk River to Seal Island.	Negligible - To sea ice from ice thickening vehicular traffic.	None anticipated.
Island - Construction	Once	3 Months	50 to 100-ft (15.2 t 30.5 m) wide subsurface berm at Seal Island for wave/ice protection.	Negligible - To sea ice from ice thickening and vertical ice movement from vehicular traffic; to island slopes from summer storm-surge induced ice floe strikes; to construction activities from vertical ice movements and seasonal ice formation/breakup.	Possible ice override.
Island - Operation/ Maintenance	Annually	15 years Rare	Island slope protection; subsurface berm; annual maintenance of berm material.	Negligible - To sea ice from island maintenance and repair activities; to operation and maintenance activities from vertical or horizontal ice movements. Minor - To island from normal ice loading and override, rubble collar, and summer storm-surge induced ice floe strikes.	Possible island facilities damage from an extreme ice override event at Seal Island.
Offshore Pipeline – Construction	Once	3 Months (Winter)	Along route and varies by route: Alternatives 2 & 3 - 6 mi (9.6 km) Alternative 4 - 9 mi (14.5 km) Alternative 5 - 8.9 mi (14.3 km)	None to Negligible - To sea ice from ice slotting, ice thickening, and vertical ice movement from vehicular traffic; to construction activities from vertical ice movement, flooding over the ice due to storms, and seasonal ice formation/breakup.	None anticipated.

TABLE 5.6-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SEA ICE

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Along route and varies by route: Alternatives 2 & 3 - 6 mi (9.6 km) Alternative 4 - 9 mi (14.5 km) Alternative 5 - 8.9 mi (14.3 km)	Negligible - To sea ice from ice thickening and vertical ice movement from vehicular traffic; to pipeline maintenance and repair activities from vertical or horizontal ice movement. Minor - To pipeline from ice gouging or strudel scour; to landfall facilities from Alternatives 2, 3, and 4 from ice pile-up.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	Negligible – To sea ice from ice thickening and vertical ice movement from vehicular traffic due to gravel hauling activities.	None anticipated.
Large Oil Spill	Rare	Unknown	Area contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Reduction of mechanical integrity from melting or oil incursion into the ice and from ice scraping or drilling during spill response.	None anticipated.
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method	Negligible - To sea ice from ice slotting if pipeline is removed.	None anticipated.

Notes:
ft = Foot
km = Kilometers
m = Meter
m^3 = Cubic meters
mi = Miles
N/A = Not applicable

CHAPTER 6.0

AFFECTED BIOLOGICAL ENVIRONMENT AND IMPACTS

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6.0 AFFECTED BIOLOGICAL ENVIRONMENT AND IMPACTS

6.1 INTRODUCTION

Chapter 6 of this Environmental Impact Statement (EIS) presents the environmental setting and potential impacts of each alternative on biological resources. This chapter addresses a range of biological resources in the vicinity of the Northstar Unit, including: plankton, marine invertebrates, fishes, marine mammals, coastal vegetation, freshwater and terrestrial invertebrates, birds, and terrestrial mammals. Threatened and endangered species are specifically addressed. Information in this chapter supports National Environmental Policy Act (NEPA) decision-making for water discharge (National Pollutant Discharge Elimination System [NPDES]) and ocean dumping (Section 103) permits. Information will also be used to assist in fulfilling NEPA requirements for Section 7 consultation under the Endangered Species Act of 1973 (ESA) and consultation for Incidental Harassment Authorization under the Marine Mammals Protection Act.

The information presented in Chapter 6 provides an understanding of the biological resources in the vicinity of the Northstar Unit. Potential impacts on biological resources associated with the construction, operation, maintenance, and abandonment of each project alternative are described. The criteria used to determine if an impact on the biological environment is potentially significant was based on the NEPA definition of significance, which requires consideration of context (as it affects populations, the affected region, and the locality) and intensity or severity of the impact. The range of intensity included none (no impact), negligible, minor, and significant as defined in Section 1.8. The analysis of intensity considered the magnitude of the impact, the geographic extent, duration and frequency, and the probability of an impact occurring.

The impact criteria for many biological resources are qualitative in this EIS, because of the lack of data on specific effects. Professional expertise and judgment, along with consideration of available scientific literature, were relied upon to derive thresholds at which impacts were considered significant and, therefore, avoidance or minimization would be required to reduce these impacts or demonstrate that the impacts are unavoidable. For evaluating the intensity of an impact to biological resources, consideration is given to whether the action affects the species populations of the geographic area (e.g., barrier islands, North Slope oil fields, Colville River drainage), as well as much larger regional populations (e.g., Arctic Coastal Plain, southern Beaufort Sea).

Chapter 6 addresses the following issues related to the project's potential impacts on biological resources:

Issues/Concerns	Section
· What impacts could gravel placement have on plankton and marine invertebrates? · What effects to plankton and marine invertebrates could occur from the turbidity plume during construction?	6.3.2 6.3.2
· How would construction discharges from Seal Island affect plankton and	6.3.2

Issues/Concerns	Section
marine invertebrates?	
· How would trenching affect plankton and marine invertebrates?	6.3.2
· How would vessel traffic affect plankton and marine invertebrates?	6.3.2
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· What long-term habitat would be created as a result of gravel mining?	6.4.2
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	6.4.2
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· How would project operations contribute to increased periods of open water that could lead to entrapment of marine mammals?	6.5.2
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· What would be the effects to the tundra of residual ice (late melting) along ice road alignments for gravel mining and freshwater sources?	6.6.2
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Issues/Concerns	Section
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· How would project operations contribute to increased periods of open water at Seal Island that could lead to entrapment of some species?	6.7.2
· How would oil affect birds?	6.7.2
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6.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge is included in this EIS in acknowledgment of the vast, valuable body of information about the Arctic that the Inupiat people have accumulated over many generations. This knowledge contributes, along with western science, to a more complete understanding of the Arctic ecosystem. Although Traditional Knowledge has been accumulating for much longer than western science, it has been maintained orally and been recorded sporadically. While such transcriptions have occurred coincident to various research efforts, they rarely have been focused directly on the topics of this EIS. Therefore, in this effort to collect references to Traditional Knowledge on specific topics such as plankton, invertebrates, vegetation, fish, mammals, and birds, the results are fragmentary and in no way represent the complete body of Traditional Knowledge on these topics.

Traditional Knowledge on the biological environment was obtained from testimony by village elders, whaling captains, and other citizens from the villages of Barrow, Nuiqsut, and Kaktovik at the majority of hearings on North Slope oil and gas development held since 1979. Information also was obtained through personal interviews with concerned citizens in and around the project area. Reviews of engineering studies and environmental reports associated with previous and ongoing oil and gas exploration and development activities provided a source of additional Traditional Knowledge. Published and unpublished scientific reports and data; and environmental reports and studies conducted by universities, the oil industry, federal and state agencies, and the North Slope Borough (NSB) also were used as sources for Traditional Knowledge.

Due to historic concerns that Inupiat people have had with offshore oil and gas development, extensive Traditional Knowledge of bowhead whales and their associated issues has been compiled from Inupiat testimony, as compared to some of the other animals. As noted by Sarah Kunaknana of Nuiqsut, who was raised near Prudhoe Bay, *"There are other animals, sea mammals, involved ... but what really concerns us is the migrating whale because [petroleum exploration is in] the path that they take during their migration."* (USDOI, MMS, Alaska, 1990:15).

Inupiat names are spelled according to the transcripts of the hearings, and some statements have been paraphrased to clarify the information.

6.2.1 Plankton and Marine Invertebrates

Inupiat Traditional Knowledge of plankton and marine invertebrates has been obtained primarily through observations of events in nature. For example, Isaac Akootchook of Kaktovik stated that, in 1964, he watched the *"Wave action of [an] earthquake hit ... the microorganisms and the planktons ... were pushed out [of the water] onto the ice."* (USACE, 1984:17). Observations have enabled Inupiat hunters to gain detailed knowledge of ecosystem relationships, as demonstrated by a statement made by Fenton Rexford of Kaktovik, who testified that crustaceans, shellfish, and shrimp are all tied into the bearded seal and the bowhead whale and added, *"If there is an oil spill out there, it will kill off all those shrimp, the crab, [and the] phytoplankton, they will all be affected."* (USACE, Alaska, 1996:43).

6.2.2 Fish

Regarding migration routes of least and Arctic cisco, Archie Brower, former Mayor of Kaktovik, stated, *"I've been catching fish that [were] tagged all the way from Prudhoe Bay over at Griffin Point ... that's about 18 miles east of here."* (USDOI, MMS, Alaska, 1982:5). Johnny Ahtuangaruak of Nuiqsut noted the Colville River is an important spawning area (USDOI, MMS, Alaska, 1982:6).

Inupiat hunters believe that high sound levels associated with seismic exploration will affect fish adversely. To demonstrate the impacts of strong sound waves on fish, Emmett Morrey of Anaktuvuk Pass stated that, when he was a young man netting fish with his father, fish would *"just roll belly up"* if his father hit a piece of willow against the ice (USDOI, MMS, 1983:32).

6.2.3 Marine Mammals

Inupiat hunters have noted that there are more polar bears than there used to be. Archie Ahkiviana, a whaling captain from Nuiqsut, noted that polar bears, *"Are getting [to be] too many,"* and added, *"One time they counted over 100 polar bears right down below Endicott."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:25-26). Hunters have observed that polar bears may be attracted to oil and gas exploration sites. Thomas Napageak, a whaling captain and President of the Native Village of Nuiqsut, stated that polar bears, *"Go toward the noise or anything that moves."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:27). Inupiat hunters also know that polar bears are sensitive to noise during the denning season. Billy Adams, representing the NSB, stated, *"Polar bears that den ... will not tolerate noise disturbance."* (USDOI, MMS, 1986:8). Nuiqsut elder Samuel Kunaknana observed that polar bears have built dens along rivers because of high snow drifts and lack of ice movement, as compared to sea ice (USDOI, MMS, 1979:5).

Inupiat residents had observations on the presence of other marine mammals in the project area. According to Samuel Kunaknana of Nuiqsut, seals occur in high numbers in April on the sea ice near Nuiqsut (USDOI, MMS, Alaska, 1982:6). Thomas Napageak noted that they migrate through the area around Nuiqsut in August and sometimes come close to West Dock (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:21). He also noted that killer whales and walrus have been observed near Narwhal Island, 20 miles (32 kilometers [km]) northeast of the project area, and a single gray whale was observed there in 1993 (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:24).

6.2.4 Birds

According to Thomas Napageak, Thetis Island, north of the Colville River delta, and Pole Island, 30 miles (48 km) east of the project area, are important nesting areas for waterfowl, including eider ducks (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:26). Isaac Nukapigak of Nuiqsut stated that the Peri Islands also are important to migrating birds (USDOI, MMS, Alaska, 1990:17). Inupiat are concerned about the birds' vulnerability to oil. Fenton Rexford, President of the Kaktovik Inupiat Corporation, stated, *"We know that there are a lot of waterfowl that come from all over the world that go through this area ... and if there is an oil spill that would have a drastic [effect] on the population."*

(USACE, Alaska, 1996:22).

6.2.5 Terrestrial Mammals

Hunters in Kaktovik have testified frequently that more caribou roamed the region in the past than do today. In 1979, Nolan Solomon of Kaktovik stated: *"There used to be lots of caribou. There used to be hundreds out there. ... Today, you can hardly see any. I think strongly because of air traffic. Small planes and helicopters fly fifty feet above the coast ... driving our caribou away from their calving areas and migrating patterns and also cause caribou to leave their young."* (USDOI, MMS, 1979:22). In 1982, Jonas Ningeok also of Kaktovik stated: *"There used to be lot of caribou here before they put up the pipeline. Ever since they put that pipeline around this area, the caribou have not been seen up here very much."* (USDOI, MMS, Alaska, 1982:25). Isaac Akootchook, a resident of Kaktovik for 68 years, stated: *"Since this development of the oil companies started, there has been a very noticeable decline [in] the caribou. You have to travel way up ... to the mountains to catch any caribou nowadays."* (USDOI, MMS, 1990:10).

According to Thomas Napageak, caribou belonging to the Porcupine Caribou Herd come as far west as Nuiqsut only if a southwesterly wind has been blowing steadily for a week and it has been warm. Otherwise, they will stop near the Sagavanirktok River. He also stated that some mixing occurs between the Western Arctic, the Central, and the Porcupine Caribou Herds prior to their moving inland (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:29).

Rossman Peetook of Barrow and Fenton Rexford of Kaktovik noted that caribou derive their salt from the ocean waters and, therefore, effects from an oil spill would also be felt by caribou. (USDOI, MMS, 1983:25). *"We .. get migrating caribou that come into the ocean for a salt lick. They have come from a long migration route and they are deficient in minerals. They go down to the ocean in little lagoons and lick the .. salty ice."* (F. Rexford in USACE, 1996:30).

6.2.6 Threatened and Endangered Species

The Inupiat Eskimo of northern Alaska have pursued the bowhead whale for generations during annual subsistence hunts. Inupiat Traditional Knowledge reflects the strong dependence of the Inupiat people on the ocean for survival. In 1996, this concern was summarized by Edward S. Itta, a whaling captain and President of the Barrow Whaling Captains Association, who testified that, *"The ocean is what holds our culture together ... [and that means] ... the [bowhead] whale."* (USACE, 1996:28). Knowledge of marine ecosystems forms the basis for Inupiat concerns regarding oil and gas development in the Arctic.

During the past 10 years, biologists have worked with indigenous peoples to integrate Traditional Knowledge into their research (Freeman and Carbyn, 1988:22; Freeman, 1992:11; Hobson, 1992:2; Albert, 1992:25; MBC, 1996:127). This interest in Traditional Knowledge is in recognition of the fact that biological studies in the Arctic are usually conducted as intensive, short-term efforts during the brief Arctic summer. In contrast, Traditional Knowledge represents the cumulative observations of people who have lived in the Arctic for many generations. This knowledge is expressed frequently because of the strong interest Inupiat have in science and resource management (Albert, 1988:18; Albert, 1990:345). Craig George, representing the NSB noted: *"There's nothing mysterious about Traditional Knowledge. Wildlife biology is largely an observational science ... the person who has the most number of observational hours has the best data .... and the cumulative hours of observation of the whaling community just dwarfs anything that's been done by the scientific community."* (USDOI, MMS, 1995:49).

6.2.6.1 Bowhead Migration Route and Timing

A number of Inupiat whaling captains have provided detailed testimony regarding the characteristics of bowhead whale migrations. Arnold Brower, then Chairman of the Alaska Eskimo Whaling Commission (AEWC) with 30 years' experience hunting bowheads, noted that spring migration occurs in three pulses, whereas fall migration occurs in two pulses (USDOI, MMS, 1986:24). However, Burton Rexford, Chairman of AEWC in 1995, with 55 years of whaling experience, stated, *"The migration routes are unpredictable due to nature's conditions."* (MBC, 1996:80). Whaling crews have observed that migrating whales appear to have 'scouts,' whales that check ice conditions in advance of the main group (C. Nageak in NSB, 1981:296; W. Bodfish in NSB, 1981:297; L. Kingik in NSB, 1981:297).

Bowheads follow open areas in the ice of the Alaskan Beaufort Sea during spring migration according to Waldo Bodfish of Wainwright (NSB, 1981:295), and generally do not stop anywhere along the migration route (V. Nageak in NSB, 1981:295). Andrew Oenga, who hunted bowhead whales as a crew member out of Barrow from 1943 to 1960, stated, *"I believe from my experience that bowhead whales would reach the leads far offshore from Prudhoe Bay by early May."* (NSB, 1980:182). The spring migration ends at Herschel Island according to Vincent Nageak (NSB, 1981:295). However, whaling crews also have noticed that not all bowhead whales follow the same migration patterns in the Chukchi or Beaufort Seas. According to Harry Brower, Jr., of Barrow, *"they're ... here [Barrow] during the summer, too."* (USDOI, MMS, 1995:85).

Bowhead whales start their fall migration back from the Herschel Island area in August (I. Akootchook in USDOI, MMS, 1995:12). The first pulse consists of bowheads migrating by the hundreds, in schools like fish (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:23). These whales are not accompanied by calves (J. Tukle in USDOI, MMS, 1986:21). The second pulse consists of females with calves (J. Tukle in USDOI, MMS, 1986:20; T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:22). Bowhead whales apparently take their time returning westward during fall migration, sometimes barely moving at all, with some localities being used as staging areas due to abundant food resources (W. Bodfish in NSB, 1981:296). For example, Susie Akootchook, who was born and raised in Kaktovik, recounted one feeding area located offshore of Kaktovik: *".. We have feeding areas for the bowhead whale in our area. Just last September [1995] we [saw] them just playing around out here."* (USDOI, MMS, 1995:18). Michael Pederson, representing the Arctic Slope Native Association, testified that: *"Areas all along the Beaufort Sea, such as Camden Bay and Harrison Bay are considered bowhead whale feeding areas. We know that they feed [there] ..... The barrier islands all along the coast are considered an important resource to the bowhead whale and are used as staging and feeding areas."* (USACE, 1996:51).

Inupiat whaler Patsy Tukle of Nuiqsut noted that the migration appears to: "*...stop when the winds are very slow ... when the weather is nice, they don't migrate. But when the winds start, [that] is when they actually start going through [Camden Bay] towards Cross Island.*" (USDOI, MMS, 1986:24). It takes about 2 days for bowheads to travel from Kaktovik to Cross Island (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:23). Andrew Oenga stated, *"I know that the whales are migrating back along the barrier islands off Prudhoe Bay by late September."* (NSB, 1980:182). It takes the whales another 5 days to reach Point Barrow from Cross Island (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:23).

Inupiat have observed that ocean currents carry food consumed by bowheads and that whales follow the currents. For example, if the currents are close to Cross Island, whales migrate near there (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). In the region immediately east of the project area, bowheads sometimes travel on the inshore side of Cross Island (V. Nageak, in Shapiro et al., 1979:A-II-23). Whales are seen inside the barrier islands near Cross Island almost every year and are sometimes also seen between Seal Island and West Dock (F. Long - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:14-15).

Bowhead whales may swim very close to shore on some occasions. Archie Brower, a whaling captain and Mayor of Kaktovik, stated, *"I have seen [bowhead] whales that feed not more than 1,500 feet offshore ... and that's only about somewhere around 15 to 20 feet of water."* (USDOI, MMS, 1979:6). At the Minerals Management Service (MMS) Arctic Synthesis Meeting in Anchorage in 1995, Burton Rexford of Barrow stated that, when he was a boy, *"Often we would observe fall migration of belukha and bowhead whales about 25 yards from the beach shoreline."* (MBC, 1996:80). Isaac Akootchook of Kaktovik reported, *"We saw whales right by the shore .. how deep it is, I don't know, but we [saw] the water [was] colored .. they hit the bottom so that [mud was suspended into the water column]."* (USDOI, MMS, 1979:15). Herman Rexford of Kaktovik noted: *" ... bowheads do travel in the shallow water, especially when feeding. They can come close to the shore ... this was when they [Inupiat] first started whaling."* (USDOI, MMS, 1979:16). Thomas Brower of Barrow noted that smaller whales may swim in water depths of 14 to 18 feet (ft) (4.3 to 5.5 meters [m]) (NSB, 1980:107).

During years when a fall storm pushes ice up against the barrier islands in the Alaskan Beaufort Sea, bowheads may, *"Migrate on the shoreward (lagoon) side of the barrier islands, where the swimming is easier."* (T. Brower in NSB, 1980:107). Crews looked for whales inside the barrier islands during the years of commercial whaling.

In the past, Inupiat whalers questioned the results of aerial censuses of bowhead whales carried out by the U.S. Minerals Management Service (MMS) in the Alaskan Beaufort Sea, based on Traditional Knowledge. Weather and mechanical problems can limit coverage of a survey area and keep planes on the ground altogether. This can affect flight surveys. Inupiat whalers on the water, however, can sometimes see whales when survey planes cannot. Whaling crews sighted 23 bowheads in the Kaktovik region during the fall of 1983 while aerial observers sighted five whales. Survey planes were: *"Going far offshore...because ice conditions were such that whales were migrating about 70 miles offshore. And they were not aware of the shore pulse."* (J. George in USDOI, MMS, 1983:23,58-59). Although the fall 1983

MMS aerial surveys were conducted for inshore, mid-offshore, and far-offshore survey blocks (Ljungblad et al., 1984:68), inherent limitations in a sampling survey mean some animals will be missed. Some limitations of aerial surveys include the fact that planes do not fly in all weather and that submerged bowheads may not be observed due to the speed of the aircraft.

Traditional Knowledge of noise effects on bowhead whales is presented in Section 9.2. Short-term and long-term displacement of bowheads due to noise disturbance from industry is also presented in Section 9.2.

6.2.6.2 Oil Spills

Inupiat concerns regarding the scale of impacts from a large oil spill in the Alaskan Beaufort Sea is a product of their understanding of ecosystem processes. For example, Fenton Rexford of Kaktovik testified: *"If there is an oil spill out there, it will kill off ... shrimp, crab[s], ... [and] phytoplankton, they will all be affected ... [they] are all tied into the whale and the ugruk [bearded seal]."* (USACE, Alaska, 1996:29-30). Archie Brower, a whaling captain from Kaktovik, testified: *"The whole place from the mountains to the ocean is just like our garden. We feed on it. If there's a major blowout on the ocean, [under the ice] if that happens, [and] the ice goes out, it's going to take that oil all along the coast ... and it would destroy our fish, seals, and whales."* (USDOI, MMS, 1979:25). Arnold Brower Jr., of Barrow, stated that, *"Any accidents of oil spill[s] would have a devastating impact to the bowhead population if [a spill were] encountered by a large migrating school that happens to want to pass through their natural migratory pattern."* (USDOI, MMS, 1990:17). Thomas Napageak, then Mayor of Nuiqsut, explained the ultimate Inupiat concern: that a reduction in the bowhead stock from mortality due to an oil spill, *" ... may result in reduction or elimination of bowhead quotas for subsistence hunters in the Inupiat community."* (USDOI, MMS, Alaska, 1990:23).

The Inupiat view that an oil spill could have serious consequences to bowhead whales derives from Traditional Knowledge that most of the bowhead whale population travels to and from the Canadian Beaufort Sea in a fairly narrow migration corridor during a fairly short time. Barrow residents have recorded seeing 300 bowhead whales migrating in a day during spring and, in 1980, 95 percent (%) of the population came through in 6 days (G. Carroll in USDOI, MMS, 1986:38). There is expectation among Inupiat men and women who testified at various hearings since 1979 that a large oil spill would have severe consequences to the bowhead whale population, as well as other wildlife, because effective cleanup measures in ice-covered waters have not yet been developed. Joann Loncar, testifying at the hearing for the Draft EIS for Diapir Field Lease Offering in June 1984 stated: *"The majority of all ... bowhead whales, migrating through the Canadian Beaufort pass [the Diapir field]. And it's not going to be one or two whales [that will be affected], it's going to be the entire herd."* (USDOI, MMS, 1983:49). The large number of bowheads that could potentially be affected by an oil spill is illustrated by a statement by Joash Tukle, a whaling captain from Barrow. During a bowhead whale hunt off Barrow in 1976, he saw: *"About 150 to 200 whales in one spot. I am not telling you now .. what somebody told me, but I was there. I saw it with my own eyes, and it is a fact."* (USDOI, MMS, 1987:47).

Dr. Mike Philo, representing Inupiat in the NSB, pointed out, *"The potential effect on bowhead whales* *[of an oil spill] is not minor, but major, because if there is an oil spill, whether it be into a lead or from the ice as it melts and goes into a lead, not just a few bowhead whales but potentially the majority, if not the whole population, could be exposed to that oil spill."* (USDOI, MMS, 1986:30). Craig George, also representing the NSB, noted, *"... an oil spill that gets into a spring lead ... can't be anything but catastrophic ... [because one year most] ... of the whales passed within two miles of the lead edge."* (USDOI, MMS, 1995:51-52).

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6.3 PLANKTON AND MARINE INVERTEBRATES

6.3.1 Affected Environment

Plankton and marine invertebrates are the basis of the food web in the Alaskan Beaufort Sea and are an important food source for fish, birds, and marine mammals. Plankton and marine invertebrates occur throughout the project area as they or their early life stages drift in the ocean currents. Abundance and distribution of plankton depend on factors of the physical (e.g., wind, currents, turbidity, nutrient availability, and light) and the biological (e.g., competition and predation) environments.

6.3.1.1 Phytoplankton

Phytoplankton are microscopic, unicellular algae which drift suspended in the water and are the primary source of fixed carbon in the sea. Additional primary production is done by epontic algae (microscopic forms living on the underside of sea ice) and benthic algae. Abundance and distribution of phytoplankton are influenced by seasonal patterns in light intensity, nutrients, and oceanographic conditions (USDOI, MMS, 1996:III-B-I). Phytoplankton abundance is greatest in water depths of less than 16 ft (4.8 m). Populations peak in late July and early August due to an increase in light intensity during the open water period. However, annual primary productivity is about the same in both offshore and nearshore waters (Horner et al., 1974:57). Estimates of annual primary productivity range from 10 to 15 grams carbon/square meter/year in the nearshore lagoon areas compared with approximately 10 grams carbon/square meter/year for offshore areas (Horner et al., 1974:61).

6.3.1.2 Zooplankton

Zooplankton include macroscopic crustaceans such as copepods, as well as larval forms of other marine invertebrates and fish (ichthyoplankton) drifting in the water column. Larger zooplankton that may have weak swimming ability include: medusae (jellyfish); ctenophores (combjellies); chaetognaths (arrow worms); and crustaceans such as mysids, euphausiids (krill), and several species of amphipods. These organisms are food for birds and marine mammals.

Abundance and distribution of zooplankton in the Alaskan Beaufort Sea are affected by oceanographic conditions resulting from the clockwise circulation of the currents in the Polar Basin gyre, wind-driven upwelling, and intrusion of warmer, more saline Bering Sea water during the summer (Carey, 1978:181). During both winter and summer, calanoid copepods generally dominate the zooplankton in terms of biomass and densities in the project area. Barnacle, crab, and polychaete larvae are also abundant during summer (Busdosh et al., 1979:11; Horner et al., 1974:45). Copepods are also abundant in shoreline waters of Simpson Lagoon (Johnson and Richardson, 1981:115) and are important prey for seabirds, shorebirds, whales, and several fish species (Craig et al., 1984:359; Lowry 1993:210). Amphipods, mysids, and euphausiids are abundant in the Alaskan Beaufort Sea (Richardson et al., 1987:138). Euphausiids, primarily *Thysanoessa raschii*, are important food items for bowhead whales (Lowry, 1993:210) and ringed seals (Frost and Lowry, 1984:389). Gammarid amphipods and mysids, often considered to be epibenthic (bottom living) species, may swim above the seafloor and be included in the zooplankton.

6.3.1.3 Epontic Communities

Epontic communities are composed of plants and animals living on or in the undersurface of sea ice (USDOI, MMS, 1996:IIIB-2). Pennate diatoms and micro-flagellates are the most abundant algae in the bottom of the ice and in the water just below the ice during spring in the Alaskan Beaufort Sea (Horner et al., 1974:40). As a response to increased light in April, epontic populations develop, peaking in May, and declining in June as the ice layer melts (Alexander et al., 1974b:49). The timing of this peak is important, because epontic organisms provide food for zooplankton prior to the phytoplankton bloom.

6.3.1.4 Benthic Invertebrates

Benthic invertebrates living within bottom sediments (infauna) or on its surface (epifauna) are affected by sea ice, which physically disturbs sediments and limits the abundance and distribution of infaunal and epifaunal organisms. In nearshore waters, bottomfast ice prohibits overwintering of most benthic species at depths of less than 6.6 ft (2 m). Invertebrate communities in these areas are formed annually by re-colonization during ice-free periods (USDOI, MMS, 1990a:III-B-3). Nearshore areas are characterized by epifaunal crustaceans (amphipods, isopods, and mysids) that are motile and opportunistic, as well as infaunal polychaetes and bivalves. Isopods often dominate the invertebrate biomass in these areas (USDOI, MMS, 1996:III B-3).

Other physical factors influencing benthic communities include sediment composition, water temperature and salinity, wave action, and input of organic material (e.g., peat). Sediment grain size influences species composition; deposit-feeders predominate in fine sediments, and suspension-feeders are more common in coarse sediments. Large fluctuations in salinity and temperature occur in the nearshore habitats of benthic organisms. In some coastal lagoons, the exclusion of salt during ice formation and reduced water movement in winter can lead to salinities up to 180 parts per thousand (ppt), which can persist until either breakup or the penetration of freshwater runoff during spring (Houghton et al., 1984:21). During spring breakup, melting ice and flooding rivers may cause hyposaline conditions (nearly freshwater), and water temperatures may reach 54 degrees Fahrenheit (°F) (12 degrees Celsius [°C]) (Feder et al., 1982:B-13). In summer, salinity in Simpson Lagoon normally ranges between 1 and 32 ppt, and water temperature fluctuates from 32° to 57°F (0 to 14°C) (Craig et al., 1984:348). Many organisms survive these fluctuations by either temporarily burrowing into the sediment or moving out of the area.

Water currents in and out of the lagoons help move invertebrates and their larvae into nearshore areas from offshore to recolonize shallow areas after bottomfast ice moves out and exposes the inshore sediments (Griffiths and Dillinger, 1980:155). Currents and wave action also aid dispersion of organic material from terrestrial sources (river deltas and coastal erosion areas) into the marine environment. Organic material, such as peat, is considered a secondary food source for benthic invertebrates (Broad et al., 1979:363). Studies in Simpson Lagoon indicate that mysids and amphipods tended to collect on detrital mats (Griffiths and Dillinger, 1980:155).

Infauna: Diversity and density of infauna in the project area is low due to physical and chemical stresses (Houghton et al., 1984:21; Craig et al., 1984:348). Annelid worms (primarily polychaetes) and bivalve molluscs dominate the infauna to water depths of approximately 33 ft (10 m) in coastal areas (Broad et al., 1979:362; KLI, 1990:20). At depths of approximately 16 to 26 ft (5 to 8 m) in Prudhoe Bay and Stefansson Sound, polychaetes were the dominant infaunal organism, while molluscs and crustaceans were less abundant (Griffiths et al., 1983:11). A 1995 study in the project area confirmed these earlier findings. Benthic samples were collected in water depths ranging from 7 to 45 ft (2 to 13.7 m) between Northstar Island and West Dock (WCC, 1996:ES-1 and 4-40). Polychaete species were predominant, representing 43% of the total fauna, while crustaceans and molluscs composed 21% and 26%, respectively (WCC, 1996:4-12).

In the shear zone, at approximately 49 to 66 ft (15 to 20 m) water depths, ice gouging disturbs bottom sediments, limiting infaunal abundance (USDOI, MMS, Alaska, 1990b:III-B-3). In water depths greater than 66 ft (20 m), biomass and diversity of infaunal organisms increase with depth and distance from shore (Carey, 1978:201). Infaunal biomass is highest at approximately the 460-ft (140.2 m) depth (Carey et al., 1974:671).

Epifauna: Epifauna are generally more abundant and diverse than associated infauna in the nearshore Alaskan Beaufort Sea and the project area. Epifauna are distributed in zones of species groups; for example, three distinct communities are found between the nearshore and offshore areas of Prudhoe Bay (Feder et al., 1982:C-127 to C-130). Epifauna species groups are segregated in the Alaskan Beaufort Sea according to water depths and tend to increase in density and diversity with increasing water depths (Carey et al., 1974:678).

Epifaunal species groups of the nearshore waters in Harrison and Prudhoe Bays and Simpson Lagoon during the summer are dominated by mysids (Alexander et al., 1974a:411-462; Griffiths et al., 1983:10-11). They apparently overwinter in offshore areas and move nearshore when the ice leaves (Griffiths et al., 1983:17). Amphipods, another major component of the nearshore epifauna, appear to occupy a wider range of salinity than mysids (USACE and ERT, 1984:3-54). The isopod *Mesidotea entomon* is a common epifaunal organism in the Alaskan Beaufort Sea (USDOC, NOAA and USDOI, BLM, 1977:116; Broad et al., 1979:362; Griffiths et al., 1983:10-11). Although it is nearly ubiquitous in its distribution and has been reported at extreme depths in other environments, it appears to select water depths of less than 16 ft (4.8 m) in the Alaskan Beaufort Sea (MacGinitie, 1955:153-154; Robilliard and Busdosh, 1979:6).

6.3.1.5 Hard-Bottom Communities

Benthic hard-bottom communities contain macrophytic algae (large kelps), benthic microalgae, and benthic invertebrates associated with rocks or other hard substrate (USDOI, MMS, 1996:IIIB-2). The Boulder Patch in Stefansson Sound near the Endicott Development (Figure 6.3-1) provides a substrate for invertebrates and the brown alga (kelp) *Laminaria solidungula* which is an important carbon producer (Dunton, 1984:312). Such kelp beds support sponges, soft corals, hydroids, sea anemones, bryozoans, chitons, nudibranchs, and sea squirts, plus mobile benthic species, such as sea stars, fish, and crabs which are attracted to these algae (Dunton and Schonberg, 1980:366-387; LGL and Dunton, 1992:Table 1-1). This type of epifauna is often associated with small isolated patches of kelp and red algae which are attached to cobble-sized rock or shell debris in mud bottoms (Toimil and England, 1980:25). These hard-bottom communities are not found in the soft bottom sediments of the remainder of the Alaskan Beaufort Sea and have not been reported in the area surrounding Seal Island. They could, however, occur on concrete pieces left when the island was abandoned or on new structures placed in the area (such as the newly developed island slopes). Provided their local habitat is not adversely altered, large epilithic species can live in the same place for many years. Conversely, colonization of suitable new habitat following a major disruption is slow, possibly taking many years (Toimil and England, 1980:25).

6.3.2 Environmental Consequences

Potential impacts of project alternatives on plankton and marine invertebrates are described in this section. Impacts to plankton and marine invertebrates are considered the same for Alternatives 2, 3, 4, and 5. Therefore, these alternatives are discussed together and summarized in Table 6.3-1.

6.3.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative, consequently, there would be no impacts to plankton and marine invertebrates. The natural variability in population levels and habitat of plankton and marine invertebrates in the Alaskan Beaufort Sea would continue undisturbed. As a result of the No Action Alternative, the existing hard-bottom community habitat that has surrounded Seal Island since it was first constructed would not be effected.

6.3.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Most construction activities for all alternatives would occur during the winter. Island slope protection and installation of offshore production facilities, however, would take place during the open water season. Gravel mining activities at the Kuparuk River Delta would not affect marine organisms because these activities would be conducted on land. Sediment disturbed by excavation at the mine site is expected to settle out in the abandoned deep pit prior to breakup, resulting in no secondary impacts from increased turbidity.

Placement of gravel to reconstruct Seal Island would build upon the existing underwater gravel structure and any remaining undisturbed soft substrate surrounding the island within the approximate 18.1-acre (7.3-hectare) Distribution of Spectacled Eider Breeding Pairs, 1991-1996 to be minor.

Figure 6.3-1 (Page 1 of 2)

Figure 6.3-1 (Page 2 of 2)

Table 6.3-1 (Page 1 of 2)

Table 6.3-1 (Page 2 of 2)

Any widening of the West Dock causeway for Alternative 5 would result in a similar type impact. Moreover, natural sediment transport processes, such as storm events and strudel scour, routinely cause high turbidity and redeposition of fine sediments. As a consequence, infaunal and epifaunal species living on muddy bottoms are adapted to high turbidity and can naturally recolonize areas of seafloor that are disturbed (USACE and ERT, 1984, Volume 2:4-139). Even if recolonization of the disturbed seafloor area did not occur, the area that would be covered by new substrate represents a small portion of the total available habitat and would be a minor impact.

Phytoplankton biomass is low in the Alaskan Beaufort Sea in winter (Horner, 1979:92) due to the combination of low numbers of individuals and very low light levels. Increases in turbidity from gravel placement would lower light levels available for primary productivity. Since primary productivity is already low this time of year, impacts would be negligible. Turbidity would return to the normal range prior to the summer plankton bloom.

Zooplankton living in the water column immediately adjacent to Seal Island may be disturbed during gravel placement and construction dewatering discharge as a result of an increase in turbidity. Some organisms would be able to swim away from the disturbance. Normal currents would carry these organisms out of the affected area. Currents also would be expected to carry new organisms into the affected area. The affected population represents only a small fraction of the zooplankton population in the Alaskan Beaufort Sea and the effects would be minor.

Infaunal and sessile epifaunal organisms on the soft bottom within the enlarged footprint for Seal Island would be buried during gravel placement. The area of burial eventually could increase by approximately 4 acres (1.6 hectares) of soft bottom as a consequence of erosion from storm action and ice gouging on the island slopes. The loss of these individuals would be a minor impact considering that they are a small portion of the total population.

Inspection of the linked concrete mats at Seal Island during August of 1995 showed hard-bottom communities are present on the mats (CFC, 1996:5). These organisms and others living on the gravel comprising the existing Seal Island slopes would be buried completely during gravel placement. Effects to this assemblage from burial and the island slope protection system concrete mats would be considered a minor impact, but this habitat would be recolonized once construction is complete.

The lower portions of the mat and new gravel substrate could provide habitat for development of hard-bottom kelp communities. These communities can have a high species diversity and provide valuable habitat for fish and invertebrates such as crabs, shrimp, starfish, soft corals, hydroids, and sea anemones (Toimil and England, 1980:25). Because the island slope would be constructed of the same materials used previously at Seal Island, it is likely that the new biological community that develops at Seal Island would be similar to that which exists now. It would provide biological diversity for the duration of operation and the island's existence. Overall, impacts to the hard-bottom communities from island construction would be minor.

The construction dewatering discharge would be subject to a NPDES permit as discussed in Appendices

F, G, and O. This dewatering operation is required for installation of a seawater intake system port and an outfall port. An average of approximately 1 million gallons per day (gpd) (3.785 million liters/day), would be discharged with a maximum rate of up to 2 million gpd (7.571 million liters/day). This discharge would occur discontinuously for 2 to 4 weeks during late winter and would be composed of untreated seawater. The discharge would be through the slot cut into the ice for pipeline placement or directly into adjacent waters. This discharge is expected to be high in settleable and suspended solids, but is not expected to transport any other pollutant. Although its sediment load may affect local biota (e.g., smother some benthic organisms), this discharge is short in duration and occurs during a period of quiescent currents. Environmental impacts are expected to be negligible.

Removal of ice from the slot cut to facilitate trenching would eliminate epontic algae and invertebrates where the slot is cut in the ice. However, the area of ice removed would be small, less than 10 acres (4 hectares) in total. Storage of excavated sediments on the ice would leave a residue on the surface of the ice. This residue would substantially reduce light transmission through the ice in the spring, causing a reduction in primary production by phytoplankton and epontic algae food available to zooplankton. The area of soiled ice could exceed 150 acres (61 hectares) in the offshore zone. However, this area is small compared to the total area supporting primary production under the ice in the Alaskan Beaufort Sea, and therefore, the impact is considered minor.

Pipeline trenching activities could produce a variety of effects on soft-bottom benthic organisms. However, in less than 6 ft (1.8 m) of water, the biota in and on sediments under the bottomfast ice would already have moved, been frozen, or likely destroyed by natural processes of ice movement prior to the commencement of construction. Therefore, adverse effects of trenching would be limited to that portion of the pipeline corridor deeper than 6 ft (1.8 m). Trenching and backfilling would affect approximately 30 acres (12 hectares) of seafloor habitat in 6 to 39 ft (1.8 to 11.9 m) deep water. Organisms contained in excavated sediments stored on the ice would die from freezing or mechanical damage. Potential effects of trenching and backfilling on organisms living in or on sediments adjacent to the trench include suffocation from burial, crushing from ice removal, and physiological stress due to increased turbidity during trenching or backfill activities. Stationary organisms such as clams and worms would be most at risk, although mobile species such as isopods and amphipods also could be affected. However, the benthic community is tolerant of similar naturally-occurring perturbations from ice gouging, strudel scour, and severe storms. Natural repopulation of the trench area by infaunal invertebrates is expected within a few years. Density of invertebrates in the offshore zone is typically much higher than in water depths less than 6 ft (1.8 m), providing good stocks to support recolonization (WCC, 1996:4-47). Impacts of trenching would be short-term and minor.

As discussed above, it is not expected that the silt plume would cause a measurable reduction in abundance of common species beyond the range of natural variability or have adverse effects on the benthic biota. Bottom disturbances such as ice gouging and strudel scour, common in the offshore zone, may mask some construction effects on benthic invertebrates as a result of mounding, deposition, and alteration of sediments during the pipe-laying process. Naturally occurring hyposaline and highly turbid conditions occurring during spring breakup could also mask construction impacts. The overall impact from pipeline trenching and backfilling on plankton and marine invertebrates would be minor and disturbed areas are expected to be recolonized after installation of the pipeline.

In view of the anticipated vessel traffic and the depth of water at the dock face (approximately 38 ft [11.6 m]), a propwash would not normally extend to the seafloor. However, propwash from large tugs bringing barges to the island could cause disturbance of bottom sediments. Effects on marine organisms from such sediment disturbance is expected to be negligible, short-term, and similar to normal storm activity and ice grounding.

Operations Impacts: Operations would require a continuous seawater supply and produce a continuous combined effluent. Any phytoplankton or zooplankton entrained in the seawater intake system and entrapped in a filtration system would be backflushed through the discharge system. A portion of the intake seawater is eventually discharged back to the Alaskan Beaufort Sea as products of several different processes: brine from a desalination plant, treated domestic/sanitary wastewater, and effluent from a continuous flush system.
These three streams are commingled and discharged through a submerged port on the south seawall of the facility. This discharge may impinge on a small area of the island's toe and could come into contact with organisms that become established on this toe. However, this discharge is not expected to contain toxic materials and would be diluted rapidly as it enters the receiving seawater.

A second discharge is an annual test of the facility's fire suppression system. The fire suppression test lasts 30 minutes and discharges back into the Alaskan Beaufort Sea up to 88,200 gallons (333,873 liters) of seawater drawn in for the test. This annual test is expected to have no impacts on local plankton and marine invertebrates because the discharge consists of untreated seawater at near ambient temperature.

Effects of an oil spill to phytoplankton would likely include reductions in primary production due to changes in the light spectrum from the effect of water soluble aromatic hydrocarbons. This could cause changes in species composition (Hsiao, 1978:104-105; Hsiao et al., 1978:220), reduce growth, or cause mortality; however, effects vary depending on which species are present, type of oil, and life-cycle (Wells, 1982:67). These changes are typically temporary as the oil will eventually disperse and repopulation of the affected area by phytoplankton from adjacent non-contaminated areas would occur within 9 to 12 hours (USDOI, MMS, 1996:IV-M-2). Impacts of oil to plankton and marine invertebrates are discussed in Chapter 8.

Maintenance Impacts: Repair and maintenance of the offshore pipelines during normal operations would cause limited disturbances, the extent and nature of which would be similar to or less than those created during construction. The impact would depend on the nature of the problem, season of occurrence, and approach used to uncover/rebury (if required) the pipe and perform repairs. During winter, effects would not be anticipated in areas less than 6.6 ft (2 m) deep because benthic organisms would have been eliminated by bottomfast ice. In pipeline segments below floating ice where free water is found, or for summer excavation, disruption to benthic species would occur as a result of pipeline excavation. Impacts would depend on actual maintenance activities. These are, however, expected to be similar to natural bottom disturbances such as ice gouging and strudel scour and are considered a short-term, negligible impact due to rapid re-colonization of these areas in summer.

Island surface grading after breakup and before freezeup is not expected to cause an impact. Maintenance and repairs of the island slope protection system would include removal and replacement of blocks. Disturbance to biological communities living on or near the repaired areas may include increased turbidity, crushing, or destruction of organisms on the removed block. This activity would have an adverse effect on a small portion of the hard- or soft-bottom benthic communities established around the reconstructed Seal Island; therefore, impacts would be considered minor.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to plankton and marine invertebrates would be expected to be similar to those generated during construction and would have a similar, minor impact. Abandonment impacts that involved removal of all facilities and infrastructure would result in the loss of the hard-bottom communities that are expected to form around Seal Island which would also be a minor impact.

6.3.3 Summary of Environmental Consequences

No significant adverse impacts were identified for phytoplankton, zooplankton, and benthic marine invertebrates, or the epontic community which lives under the sea ice, from the development of the proposed project. Winter construction minimizes adverse impacts to marine biota because fewer organisms are present and primary productivity is already low. The impacts identified as a result of construction of Seal Island trenching and burial of the pipeline include mortality from direct burial, smothering, and displacement.

Alternative 1 will result in no impact to the seasonal bloom of phytoplankton and zooplankton or the development of the epontic community growing on the under side of the stable ice during the spring. With this alternative, existing population numbers and productivity will continue to fluctuate seasonally with a range of natural variation.

The development of Alternatives 2, 3, 4, or 5 will result in minor impacts to marine invertebrates from construction of Seal Island through smothering of organisms under the footprint of the island and burial existing hard-bottom communities presently growing in the surrounding area. The trenching for the pipeline will impact both infauna and epifauna through direct physical disturbance, burial with sediment, or from increased turbidity in the surrounding waters. Trenching the shallow waters of the lagoon would have a negligible effect on benthic invertebrates. Impact to marine invertebrates in deeper waters would be considered minor because of the rapid recolonization and geographic range of these species. Impacts of water discharges at Seal Island on plankton and marine invertebrates are considered negligible.

Development of the Seal Island and trenching and burial of the offshore pipeline could result in short-term impacts to plankton and marine invertebrates. Plankton would be rapidly replaced by reproduction or from adjacent areas. Recolonization of the disturbed bottom substrates would occur after construction and long-term productivity of the impacted area would not be adversely affected. The operation of the pipeline and facilities would have no long-term impacts on plankton or marine invertebrates. Maintenance activities that require offshore pipeline repair would have negligible impacts to plankton and marine invertebrates.

The development of any of these alternative would result in no irretrievable or irreversible commitment of marine invertebrate resources. Recolonization of the areas affected would replace lost biomass.

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6.4 MARINE AND FRESHWATER FISH

6.4.1 Affected Environment

Fishes inhabiting the project area fall into three groups: 1) freshwater species limited primarily to freshwater habitats; 2) "anadromous" species that migrate from marine waters to freshwater to spawn, and "amphidromous" species that migrate between freshwater and marine water for purposes other than spawning; and 3) marine species. Fish resources are an important part of the subsistence lifestyle of the Inupiat residents of the Arctic Coastal Plain which is discussed in Section 7.3. The term "anadromous" will be used in this document to refer to fish that spend time in both freshwater and marine environments (Craig and Skvorc, 1989:29). The common name "char" will be utilized in this document to refer to the anadromous chars of arctic drainages which have been called both Arctic char (*Salvelinus alpinus*) and Dolly Varden (*Salvelinus malma*) (Morrow, 1980:58-61). Recent taxonomic studies support the theory that they are a northern form of Dolly Varden (Reist et al., 1997; Craig and Skvorc, 1989:30).

This discussion incorporates information from the following reviews and emphasizes information obtained within the project area or that may be directly applicable to impact analysis. Alaskan Beaufort Sea fish resources have been reviewed in a number of previous documents including: study reports (USDOC, NOAA, 1978:220-231), Environmental Assessments (Dames & Moore, 1988:3-39 to 3-57), EISs (USDOI, MMS, 1990:III-B-5 to III-B-10; 1996:III-B-3 to III-B-6), and publications (Craig and Skvorc, 1989:27-54). Fechhelm et al. (1995:1-29) reviewed fish resources specifically associated with the Northstar Unit.

Nearshore Habitat: Nearshore areas are especially important to most fish species of the Alaskan Beaufort Sea (Table 6.4-1). For purposes of this discussion, nearshore is defined as that portion of the marine environment between the Alaskan Beaufort Sea coast and the outer side of the barrier islands. These waters are shallow, generally less than 10 ft (3 m) deep. Shorefast ice freezes to the bottom within most of the nearshore zone, limiting fish use to the short, but important, open water period from late June to October. The nearshore zone between the Colville River and the eastern edge of the Sagavanirktok River Delta, including Simpson Lagoon/Gwydyr Bay, has been studied extensively, with emphasis on anadromous fish species. This area is of particular interest because it overlaps the Northstar Unit area and offshore pipeline transportation corridors.

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It is generally accepted that shallow, brackish, nearshore marine areas in the Alaskan Beaufort Sea are important habitats during the open water season for anadromous and marine species (USDOC, NOAA, 1978:220-222; Morack and Rogers, 1984:270-273; USDOI, MMS Alaska, 1990:III-B-5 and B-7). In particular, Simpson Lagoon/Gwydyr Bay provides a migratory corridor between the Colville River and Prudhoe Bay (Fechhelm et al., 1995:21). The lagoon system also provides important feeding habitat containing abundant invertebrate prey during the summer (Craig and Haldorson, 1981:522). Preferred invertebrate food items tend to be associated with low to intermediate salinity (0 to 20 ppt) and relatively warm water conditions of 30.7 to 42.8°F (-0.7 to 6°C) that are typical of the lagoon area with temperatures as high as 60°F (15.4°C) in late June (Houghton and Whitmus, 1988:4; Cannon et al., 1991:171-172; Fechhelm et al., 1993:471). Little is known about distribution of biologically important marine species in this region; however, Arctic cod distribution tends to be associated with the transition zone between cold, saline marine waters and warmer, less saline water that results from coastal drainage (Moulton and Tarbox, 1987:48).

Offshore Habitat: Offshore habitats are defined as marine areas between the seaward side of the barrier islands and the pack ice zone in water depths from 10 to 165 ft (3 to 50.3 m). Most of the project area and proposed production and transportation facilities are located in the offshore habitat zone. This zone thaws during the short summer open water season and becomes covered with landfast ice in the winter (Section 5.6). The ice cover in the offshore zone does not reach the sea bottom at most locations, thus fish have access to the area year-round. In contrast to the nearshore zone, relatively few biological investigations have targeted the offshore area.

6.4.1.1 Freshwater Fish Species

Except for the Kuparuk River, watersheds of streams between Prudhoe Bay and Milne Point (East Milne Creek and Sakonowyak, and Putuligayuk Rivers) (Figure 6.4-1) are tundra drainages that freeze to the bottom by late winter. The Kuparuk River, a larger stream with some year-round flow, contains Arctic grayling *(Thymallus arcticus)*, round whitefish *(Prosopium cylindraceum)*, ninespine stickleback *(Pungitius pungitius)*, and slimy sculpin *(Cottus cognatus)* (Bendock, 1979:687).

Arctic grayling is the most important freshwater species in the project area. It is valuable to sport and subsistence fisheries and spawns in shallow stream areas in early spring, immediately after breakup. Eggs hatch in a few weeks and the young fish rear in shallow stream areas until declining stream flow in the fall forces them downstream to wintering areas. Adult and juvenile grayling disperse widely during the open water season to stream or pond feeding areas and move to wintering areas prior to freezeup.

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6.4.1.2 Anadromous Fish Species

Arctic cisco (*Coregonus autumnalis*), least cisco (*Coregonus sardinella*), char (*Salvelinus* species [sp]), and broad whitefish *(Coregonus nasus*) are the most abundant anadromous fish species in the project area. Table 6.4-1 summarizes directional fish trap net (a long, bag-shaped trap held open by hoops) catch data for 10 years of Endicott Project fish monitoring studies from Simpson Lagoon to the east side of the Sagavanirktok Delta. These data provide a good indication of species presence and proportional abundance in the nearshore zone during open water. Four anadromous species (Arctic cisco, least cisco, char, and broad whitefish), combined with Arctic cod *(Boreogadus saida)* and fourhorn sculpin *(Myxocephalus quadricornis)* (among marine species) make up 94% of the total catch (USDOC, NOAA, 1978:220).

A comparison of the relative abundance of the six most common species collected within Gwydyr Bay with the overall Endicott Project catch (Table 6.4-2) shows that nearshore fish species composition within the project area is similar across the Colville to Sagavanirktok River region. This comparison shows that least cisco, char, and fourhorn sculpin are more abundant in Gwydyr Bay than in other shoreline areas; whereas Arctic cod and Arctic cisco are less abundant.

Arctic Cisco: Arctic cisco *(Coregonus autumnalis)* have a complex and unusual life history which has only recently been understood. Figure 6.4-1 shows the distribution and movements of young-of-the-year (recently hatched fish), juvenile and sub-adult fish, and prespawning adults. Alaskan Beaufort Sea Arctic cisco are believed to originate from spawning stocks in the MacKenzie River of Canada (Gallaway and Britch, 1983:15-20). Young-of-the-year Arctic cisco leave the MacKenzie River and spread out along the Alaskan and Canadian Beaufort Sea coast in summer. The extent of summer movement is determined largely by coastal, wind-driven currents, which transport the small fish. Prevailing currents move these young fish westward and, in some years, they reach Simpson Lagoon by late August (Gallaway, 1990:141). Prior to freezeup, the fish move to wintering areas in the lower Colville and Sagavanirktok Rivers. In subsequent years, juvenile and sub-adult Arctic cisco spend their summers in Alaskan Beaufort Sea nearshore areas and their winters in the Colville and Sagavanirktok Rivers. They reach sexual maturity at 7 to 8 years, then move back to the MacKenzie River to spawn and do not return to the Alaskan Beaufort Sea.

Least Cisco: Least cisco *(Coregonus sardinella)* present between the Colville and Sagavanirktok Rivers originate from spawning stocks in the Colville River (Craig and Haldorson, 1981:468). Following breakup each summer, Colville River fish disperse both east and west along the coast, with some fish passing through Simpson Lagoon/Gwydyr Bay and traveling as far east as the Sagavanirktok River Delta (Figure 6.4-2). In the fall (late August to early September) the fish return to overwintering areas in the Colville River, again passing through Simpson Lagoon/Gwydyr Bay. This movement pattern occurs in all years for larger cisco; however, the movements of smaller least cisco are determined in part by wind and current. Smaller fish reach the eastern end of Gwydyr Bay in only about 1 out of every 2 years (Fechhelm et al., 1994:897-898).

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Distribution of least cisco in Simpson Lagoon/Gwydyr Bay is similar to Arctic cisco, with highest concentrations of fish occurring near mainland and island shorelines. Least cisco prefer warm, low salinity water and generally are less tolerant of high salinity water than Arctic cisco. While older least cisco tolerate salinities up to 20 ppt (Reub et al., 1991:58), abundance of young fish decreases at water temperatures below 39°F (4°C) and salinities greater than 15 ppt.

Broad Whitefish: Spawning populations of broad whitefish *(Coregonus nasus)* are present in both the Colville and Sagavanirktok Rivers. The Colville River is an important spawning area for broad whitefish (J. Ahtuangaruak in USDOI, MMS, 1982:6). All age groups enter nearshore coastal areas to feed during the open water season and return to river overwintering areas in the fall (Figure 6.4-2). Small broad whitefish are not expected in the project area. Adult broad whitefish have a greater salinity tolerance than younger fish, up to 15 ppt (Reub et al., 1991:57); therefore, they disperse farther along the coast, including Gwydyr Bay. Recent evidence suggests that most of the broad whitefish found on the Kuparuk Delta originate from the Colville River (Cronin et al., 1995). Therefore, adult broad whitefish, like least cisco, utilize Simpson Lagoon as feeding habitat and a brackish water travel corridor between the Colville River and areas to the east. Most travel occurs within the lagoon system, although a few fish have been caught along the outer shore of the barrier islands.

Char: Char (*Salvelinus* sp.) are generally distributed across the entire nearshore Alaskan Beaufort Sea during the open water season (Figure 6.4-3). Spawning populations are present in the Sagavanirktok and Canning Rivers, and tributaries of the Colville River. Most char in the project area originate from Sagavanirktok River stocks (Craig and Haldorson, 1981:566). Char usually spend 2 years in freshwater prior to migrating to the Alaskan Beaufort Sea for the summer, but are able to tolerate a wide range of salinity and temperature. They return to rivers to overwinter and/or spawn in the fall. Sampling shows that char abundance in nearshore areas near the Northstar Unit is highest in early and late summer, while mid-summer abundance is low (Cannon et al., 1987:119-121). This pattern suggests that char move from the rivers to offshore feeding areas where they spend much of the summer, passing through nearshore areas on the outward and inward legs of their migratory journey. It should be noted, however, that Craig and Haldorson (1981:470) found char in Simpson Lagoon/Gwydyr Bay throughout the open water period. Stomach contents of char collected in September 1985 and 1986 included epontic crustaceans that inhabit the undersides of ice floes, providing indirect evidence that some char are feeding amid offshore ice floes, at least during September (Cannon et al., 1987:39).

6.4.1.3 Marine Fish Species

Numerous marine fish species have been caught in the nearshore Alaskan Beaufort Sea (Table 6.4-3). Arctic cod, Canadian eelpout, and various sculpins made up 70% of the catch during trawl surveys in the eastern Chukchi and Alaskan Beaufort Seas (Frost and Lowry, 1983:2). Limited surveys with small mesh trawls at 33 to 46 ft (10 to 14 m) depths from Pingok Island to West Dock were dominated by Arctic cod, with fourhorn sculpin and snailfish commonly encountered (Craig and Haldorson, 1981:437; Tarbox and Spight, 1979:2-11; Moulton and Tarbox, 1987:45). Fine mesh surface tow nets have provided information on small pelagic fish and planktonic fish larvae in the area north of West Dock (Dames & Moore, 1989:6; Thorsteinson et al., 1991:35). These studies demonstrated the abundance of Arctic cod, and found that planktonic cod larvae were common in surface waters in late summer, along with larvae of snailfish, capelin, and sculpins.

Offshore fish sampling has not occurred frequently during the winter in the Alaskan Beaufort Sea. A variety of under-ice nets were used at two sites east of the project area (Craig and Haldorson, 1981:455) (Table 6.4-3). Only two species were caught, Arctic cod and snailfish, with Arctic cod dominating the catch. Very little is known about the distribution of marine species under the ice during the long Arctic winter.

Arctic Cod: Arctic cod is considered an important food source for marine mammals and larger fish and is the most abundant fish in nearshore habitats (USDOI, MMS, 1996:III-B-5). Distribution ranges from shoreline habitats to the edge of the pack ice. This wide-ranging, circumpolar marine species spawns in mid-winter (January and February) at unknown locations near the coast. Arctic cod larvae appear in the sea in May to July, with the larval stage lasting about 2 months (WCC, 1979:A-2). Transition to juveniles usually occurs in August.

In general, Arctic cod are more abundant in nearshore habitats during the latter half of the open water season, probably in response to favorable salinity (10 to 20 ppt) and warmer temperature conditions (Reub et al., 1991:58). The inshore intrusion of marine waters that accompanies reduced freshwater input and westerly winds late in the open water season may cause cod to move shoreward into lagoon areas. While in Simpson Lagoon, the distribution and feeding habits of Arctic cod are similar to those of anadromous species.

Some evidence suggests that Arctic cod are attracted to structures in the water, such as ice floes, docks, and drilling islands, in both summer and winter (Tarbox and Spight, 1979:2-40). Average density of Arctic cod in August 1978, offshore from Prudhoe Bay, West Dock, and Stump Island, was found to be 9 fish/35,314 cubic ft (9 fish/1,000 cubic m) in water at depths ranging from 6 to 19 ft (2 to 6 m) and 0.2 fish/35,314 cubic ft (0.2 fish/1,000 cubic m) at depths greater than 19.6 ft (6 m) (Tarbox and Spight, 1979:2-17).

6.4.1.4 Sport and Commercial Use of Fish Resources

Limited sport fishing occurs in the Alaskan Beaufort Sea and in the project area, or within freshwater in the project area. Oil field workers fish for Arctic grayling in old gravel pits in the Kuparuk oil field that have been rehabilitated as deepwater fish habitat to support fish. Occasional fishing for char occurs at the mouth of the Putuligayuk and Sagavanirktok River drainages.

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Commercial use of fish resources of the Alaskan Beaufort Sea is limited to one small, family-owned gill net fishery in the Colville River Delta that has operated since 1967 (Griffiths et al., 1983:8). Arctic cisco, least cisco, and broad whitefish are the primary species caught. The commercial catch is sold for human consumption and dog food in Fairbanks and Barrow (USDOI, MMS, 1996:III-B-5). Average annual catch, for the subsistence (Section 7.3) and commercial fisheries combined, for the 1985 to 1995 period on the Colville River Delta was 44,503 Arctic cisco and 19,533 least cisco (Moulton, 1996:27). In 1993, the exploitation rates by subsistence and commercial fisheries combined were 13% and 4.5% of estimated populations of catchable-size fish for Arctic and least cisco, respectively (Moulton, 1996:27, 40, 44). Studies indicate that catch levels were well within acceptable ranges (Griffiths et al., 1983:14; Moulton et al., 1990:34-37). Catches of Arctic cisco are linked to the recruitment of young-of-the-year from the MacKenzie River, because recruitment determines the number of catchable fish 5 to 7 years later (Moulton et al., 1991:154). Catches of least cisco appear to be related in part to environmental conditions on the Colville River Delta.

6.4.2 Environmental Consequences

The following section describes the potential impacts of each project alternative on marine and freshwater fish resources. Impacts to freshwater and marine fish are expected to be the same for Alternatives 2, 3, 4, and 5. Therefore, potential impacts of these alternatives to freshwater and marine fish are discussed together and summarized in Table 6.4-4.

6.4.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative, consequently, there would be no adverse impacts to fish. The natural variability in population levels and habitat of fish in the Alaskan Beaufort Sea would be undisturbed by a No Action Alternative. As a result of the No Action Alternative, no new deepwater fish overwintering habitat would be created at the Kuparuk River Delta mine site or at Seal Island in the Alaskan Beaufort Sea.

6.4.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Gravel removal would be conducted in the winter and would occur in a high water channel of the lower Kuparuk River isolated from the river water; therefore, no direct impacts to freshwater fish would occur. Upon completion, the pit would be connected by a channel to the Kuparuk River and allowed to flood during breakup. The completed pit would result in the creation of a 30-acre (12 hectare) lake up to 40 ft (12.1 m) deep and would include at least 4 acres (1.6 hectares) of shallow water, 6 ft (1.8 m) deep along the south side of the mine site. Because of the elevation and proximity to Gwydyr Bay, the rehabilitated mine site would become brackish. Similar restoration of gravel mines has been conducted at several locations within the project area, such as Sag C and Put 27 gravel mines (Hemming, 1995:32). The flooded pit is

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expected to provide overwintering and summering habitat for anadromous fish; therefore, the long-term impact to fish from gravel mining for the project would be beneficial. Species likely to benefit from such habitat include least cisco, broad whitefish, and juvenile Arctic cisco.

Only marine fish would be present during placement of gravel to reconstruct Seal Island. Marine fish could be impacted by an increase in turbidity at the island site, noise from pile driving, and smothering of prey organisms within the approximate 18.1-acre (7.3 hectare) footprint of Seal Island. Direct mortality to some slow-swimming fish species, such as snailfish and sculpin, also could occur from gravel placement. Low fish densities, combined with the likelihood of escape by most fish, indicate that such an impact to the food web would be negligible. The increased turbidity surrounding the island as a result of gravel placement would reduce available habitat to marine fish during the construction period. As noted in Section 6.3, less than 160 acres (64.8 hectares) of seafloor would be impacted by a silt plume when reconstructing the gravel island (if a predominate current exists at the time of gravel placement, this acreage may decrease by a factor of two or more). To avoid the more turbid portions (e.g., 100 mg/L or greater suspended solids concentrations) of this silt plume, fish transiting near Seal Island may have to swim somewhere between 1,000 to 2,000 ft (304.8 to 609.6 m) around the silt plume. This silt plume would dissipate upon completion of gravel placement. Given the large area of other available habitat, impacts to fish would be minor.

The Kuparuk Deadarm mine site, located approximately 5 to 6 miles (8 to 9.7 km) up the Kuparuk River (Figure 4-8), would be the most likely source of freshwater for ice road construction. The site is within 3 miles (4.8 km) of BP Exploration (Alaska) Inc.'s (BPXA's) proposed Northstar gravel mine location in the Kuparuk River delta and could be accessed by an ice road on the Kuparuk River. Although fish are present in the Kuparuk Deadarm mine site, it is sufficiently deep for removal of up to 100 million gallons (378 million liters) of water per year (as allowed by the State of Alaska under Permit No. ADL 75979). Water extraction for the project is estimated to range from approximately 13.1 million gallons (49.6 million liters) per year (Alternative 2) to 15.3 million gallons (57.9 million liters) per year (Alternative 4), or approximately 13% to 15% of the permitted amount. Based on the small amount of drawdown and screened intakes to prevent entrainment of fish, no impacts to freshwater fish are expected.

Installation of the seawater intake system and a discharge port requires trench dewatering on the island. This dewatering discharge is a one-time event lasting roughly 2 to 4 weeks in late winter, with an average flowrate of 1 million gpd (3.8 million liters/day) and maximum flowrate as high as 2 million gpd (7.6 million liters/day). The water will be discharged directly into the Alaskan Beaufort Sea via either a slot in the ice or into waters adjacent to the island. The discharge water would contain no contaminants, although initially it would have a high turbidity due to the presence of the suspended sediments. The slot described above is also used for trenching and subsea pipeline placement. The fish most likely to be near this activity is Arctic cod. This species is unlikely to suffer any physiological stress from the presence of suspended solids in the discharge because they can avoid high turbidity areas. There would, nevertheless, be some reduction in available habitat around the island. However, the loss of this habitat beyond the island's footprint from construction activities is temporary. The primary impact would be a decrease in available habitat covered by the island's expanded footprint; however, in view of the large area of the Alaskan Beaufort Sea relative to the area of impact, impacts to marine fish would be negligible.

Other marine species, such as snailfish and sculpin, that are oriented to the seafloor are more likely to be affected. Because these species should repopulate the seafloor affected by the silt plume, its impact is short term in the context of fish populations as a whole; therefore, impacts within the silt plume area would be negligible.

Installation of the subsea pipeline would be limited to the period of full ice cover. Anadromous fish would not be expected to be present in marine waters during this time period, and all species would be excluded from nearshore areas by bottom-fast ice. A short-term modification of the nearshore habitat would occur from trenching and burial of the pipeline. Therefore, impacts to anadromous fish from trenching are likely similar to those stresses resulting from natural ice gouging events.

Marine fish could be affected by trenching activities associated with offshore pipeline construction, possibly causing direct mortality due to mechanical action, noise, smothering due to displaced sediments, increased turbidity, altered bottom composition, and altered bottom topography. Local residents have noticed that fish are sensitive to noise pressure (E. Morrey in USDOI, MMS, 1983:32).

Remaining sediment after the completion of the offshore pipeline construction will be stored temporarily in areas away from the construction site. The sediment will be placed on the ice surface to a depth of approximately 1 ft (0.3 m). Residual sediment will be left along the corridor paralleling the pipeline route and should be no more than 1 inch (2.54 centimeters [cm]) thick. The area of soiled ice could extend to more than 150 acres (61 hectares) which includes the area along the trench and the disposal area outside the lagoon. The residue left on the ice will probably have an insulating effect on the underlying sea ice, reduce light transmission through the ice in spring, and increase turbidity in the water as it melts. Sediment suspension and deposition in the area from trenching backfilling and temporary storage of sediment would likely produce a plume after melting. Due to the low rate of under-ice current flow in the region, it is expected that most sediment would be deposited on the bottom within 0.6 miles (1 km) of the storage site; trench tests in 1996 suggest within 1,000 feet (304.8 m)(Montgomery Watson, 1996:Tables 1 and 2). The primary impact would be a temporary decrease in available habitat; however, in view of the large area of the Alaskan Beaufort Sea relative to the impact zone, the impact to marine and anadromous fish is considered negligible.

Within the floating ice zone, marine fish density is low and impacts from turbidity and mechanical disturbance of the seafloor would be limited to a narrow area. Most fish would move away from the disturbance, as a result of the temporary reduction in available habitat. Fish in the immediate vicinity could be subjected to abnormal stress, causing increased utilization of fat reserves and reduced winter survival. Effects of pipeline installation on marine fish under the ice would be expected to be localized and temporary. The silt plume associated with any particular section of pipe will be dispersed within no more than a few days after the pipe is buried. Given the large surrounding area and low density of fish, impact to local fish populations from offshore pipeline construction would be considered minor.

In the lagoon area, redistribution of seafloor sediment from wave action and ice movement would tend to cause the pipe trench backfill to blend with the existing bottom surface in a few years. Seafloor irregularity would not cause major alteration to ocean currents or affect the configuration of coastal water masses that are important to anadromous fish. Impact to fish from seafloor alterations and changes in shoreline configuration after pipe installation would be negligible.

The proposed onshore pipeline route does not cross any fish streams except the Putuligayuk River. Two additional vertical support members (VSMs) would be installed at the river crossing to support the new pipeline. Pipeline routing avoids all large ponds that might contain fish, and lakes and ponds adjacent to the route would not contain fish during winter. VSM installation would occur during winter when sediments are frozen and fish are not present. Therefore, no impact to freshwater fish from onshore pipeline construction would occur.

Operation Impacts: The completed gravel island would slightly reduce the amount of open water habitat available to marine fish, but would also increase the diversity in an area of relatively uniform soft-bottom, 39 ft (11.9 m) deep marine habitat. As described in Section 6.3, the diversity and abundance of marine invertebrates would likely be higher on the slopes of the island than on the seafloor surrounding it. It is likely that some marine fish would be attracted to the island to feed on these organisms and because of the seabed topography near the island compared to the surrounding Alaskan Beaufort Sea ecosystem. Arctic cod are thought to be attracted to structures such as gravel islands in both summer and winter (Tarbox and Spight, 1979:2-40). Other species, such as snailfish, might be attracted to the hard-bottom substrate on the armored slopes of the island. The presence of an enlarged gravel island with armored slopes would likely enhance habitat for most marine fish. Due to the increased presence of fish and benthic organisms, seals may become attracted to Seal Island, particularly after the project is decommissioned and if the island slope protection is left in place during abandonment. On balance, the long-term impact of a reconstructed Seal Island would likely be beneficial to marine fish species, lasting through the projected operating period of 15 years and continuing after abandonment as long as the island remains in place.

Operations on the gravel island are not expected to contribute to increased periods of open water. Therefore, no impacts to marine fish species from additional open water are expected.

Operational discharges from the production facilities into the marine environment would include: system flushwater, desalination brine, and treated domestic/ sanitary wastewater, all mixed together prior to discharge, plus water from an annual test of the island's fire suppression system. The discharge(s) from the fire suppression system tests are made using fire monitors (large movable water cannon-like devices) where the test water is seawater. These effluents require NPDES permitting (Appendices F, G, and O). The discharge related to the system flushwater, desalination brine, and treated domestic/sanitary wastewater requires a mixing zone to ensure adequate dilution. This mixing zone is small (16.4 ft [5 m] across) and is designed to ensure water quality standards are met at its boundary. The principal pollutant requiring dilution in this mixing zone is temperature and, occasionally, fecal coliform. The fire suppression system test discharges are not expected to contain pollutants. Because of the small size of the mixing zone and the nature of the pollutants, no detectable effects to fish from the discharges are anticipated, and impacts are considered negligible.

Potential effects of an oil spill on fish would include direct mortality from oil toxicity, chronic physiological or behavioral changes, destruction of food organisms, and habitat destruction. Actual effects would depend on many variables, including the amount of oil spilled, species and age composition of fish present, success of cleanup, time of the year, and weather factors. Impacts of a large oil spill to freshwater, anadromous, and marine fish are discussed in Chapter 8.

There are no data documenting noise effects on fish in the project area. Noise studies in other locations have been limited to the analysis of fish communication, only one study that was relevant to noise impacts on fish was found during a comprehensive literature search. In that study, a 4-month pilot project in Bodega Bay, California (Klimley and Beavers, 1997:1), 13 rockfish (*Sebastes* sp.) were tested individually in an enclosure for their responses to playback of the sound used for the acoustic thermometry of ocean climate project. The sound pressure level was 145.1 decibels (dB) at 3.2 ft (1 m) and 109.5 dB at 39.4 ft (12 m) from the speaker. The researchers did not observe much movement by the fish and there was little difference in fish behavior during experimental playback compared to control periods. Had the sound pressure levels used in the experiments been higher, they may have elicited an alarm response among the rockfish. The general threshold of response for rockfish to impulsive sounds made by an air gun used in geophysical surveys was 180 dB, but responses were detected in some fishes at levels as low as 161 dB (Pearson et al., 1992:1343-1356). At this level, blue rockfish milled in tighter circles and black rockfish moved to the bottom. Olive rockfish either moved up in the water column or descended to the bottom where they became immobilized. Based on the rockfish pilot study, only very loud noises (over 160 dB) are expected to affect fish. Different fish species probably respond differently to noise; therefore, effects on Alaskan Beaufort Sea fish may not be the same as for rockfish. Since all noise from the project (except seismic) would be less than 138 dB at 0.6 miles (1 km) from the facilities (Chapter 9), impacts of noise on fish are expected to be minor.

Maintenance Impacts: Repair and maintenance of the offshore pipelines during normal operations would cause limited disturbances, the extent and nature of which would be similar to or less than those created during construction. The impact would depend on the nature of the problem, season of occurrence, and approach used to uncover/rebury (if required) the pipe and perform repairs. During winter, effects would not be anticipated in areas less than 6.6 ft (2 m) deep because fish would not be present due to bottomfast ice. In pipeline segments below floating ice where free water is found, or for summer excavation, disruption to marine and anadromous fish would occur as a result of pipeline excavation. Impacts would be dependent on actual maintenance activities. These disruptions and temporary displacement from habitat are, however, expected to be similar to pipeline construction and would be a minor impact.

Maintenance and repairs of the island slope protection system likely would include installation of replacement blocks and maintenance of the gravel berm. The scope of these activities would depend upon the severity of damage from wave and ice actions. Island surface management and maintenance and repairs also would be carried out on an ongoing basis. Fish could be directly affected by disturbance and noise and indirectly affected by reduction in invertebrate prey species disturbed by maintenance activities. Impacts, therefore, would be localized around the island and temporary (duration of the activity), and impacts to fish resources would be negligible.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to freshwater and marine fish would be expected to be similar to those generated during construction and would be considered minor impacts.

6.4.3 Summary of Environmental Consequences

No significant unavoidable adverse impacts to fish resources from project development would occur. Implementation of Alternative 1 (No Action) would result in no impact to existing fishery resources. The Colville River fishery would continue to experience fluctuations in population levels within the range of natural variation. Reconstruction of Seal Island and trenching of the buried pipeline (associated with Alternatives 2, 3, 4, and 5) would result in a temporary increase in turbidity and subsequent short-term displacement of local fish populations in water deeper than 6.6 ft (2 m).

Overall, construction of the project is expected to result in minor, short-term impacts to local fish populations due to displacement and loss of habitat. No adverse effects from construction or operation are anticipated which would affect the long-term productivity of this fishery.

Reclamation of the mine pit on the Kuparuk River delta and the side slopes of Seal Island would be beneficial to fish. Creation of additional deep water and overwintering habitat would result in a positive increase in long-term productivity due to a potential improvement to fish habitat.

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6.5 MARINE MAMMALS

6.5.1 Affected Environment

Marine mammals of the offshore ecosystem in the Alaskan Beaufort Sea include: bowhead whales; beluga whales; ringed, bearded, and spotted seals; and polar bears (Table 6.5-1). The bowhead whale is listed on the endangered species list and is discussed in detail in Section 6.9 and the Biological Assessment found in Appendix B of this EIS. Walrus and gray whale seldom occur in the project area (Moore and Clarke, 1992: 3; Fay, 1982:7). These species are generally geographically limited to the westernmost part of the Alaskan Beaufort Sea, and are therefore not discussed further in this EIS.

6.5.1.1 Beluga Whale

The white or beluga whale *(Delphinapterus leucas)* (Qilalugaq) is the smallest cetacean regularly found in the Chukchi and Alaskan Beaufort Seas. Although commonly associated with ice and seasonally migratory in response to the advance and retreat of seasonal sea ice, they are not ice-dependent.

Belugas occur seasonally in the Alaskan Beaufort Sea, migrating through in spring and fall to and from their summer range in the Canadian Beaufort Sea (Figure 6.5-1). The western Alaska (Bering, Chukchi, Beaufort Seas) population of belugas winters at the edge of the pack ice in the central and southern Bering Sea and in

Figure 6.5-1 (Page 1 of 2)

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Table 6.5-1 (Page 1 of 1)

open polynyas (permanent openings) of the northern Bering and southern Chukchi Seas (Hazard, 1988:200). Some whales from this stock remain in bays, lagoons, and estuaries of the eastern Bering and Chukchi Seas into the summer, while others continue north in the spring, traveling north of the project area, following nearshore lead systems in the eastern Chukchi Sea to Point Barrow and then eastward through offshore leads in the central Alaskan Beaufort Sea to the MacKenzie River Delta area of the Canadian Beaufort Sea (Hazard, 1988:201).

Belugas often migrate in groups of 100 to 600 animals (Braham and Krogman, 1977:3). The spring beluga migration usually coincides with the bowhead whale migration, with both arriving in the Canadian Beaufort Sea in May and June (Hazard, 1988:205). Research suggests that the summer distribution of belugas is influenced by prey availability, ice conditions, and water temperatures (Frost and Lowry, 1990:54-55). Belugas generally are common off shorefast ice near the Colville River Delta until late June or mid-July, but are sparse or uncommon in ice-free waters of the Alaskan Beaufort Sea in late July and early August (Hazard, 1988:205). The fall migration across the Alaskan Beaufort Sea extends from August or early September through October (Seaman et al., 1986:207-208). Most of this westward fall migration takes place along the pack ice edge, seaward of the continental shelf and well offshore (Seaman et al., 1986:207; Treacy, 1994:47), although belugas have been observed frequently throughout the open water zone (Treacy, 1991:43; 1992:41; 1993:47; 1994:51; 1995:47-49). Belugas are absent from the Alaskan Beaufort Sea from November through about March (Seaman et al., 1986:27).

The total western Alaskan population of belugas is estimated to be at least 50,000 (Small and DeMaster, 1995:35). Of this total, approximately 38,000 are thought to summer in the Canadian Beaufort Sea and Amundsen Gulf. This western Alaska population appears stable and may be increasing (Small and DeMaster, 1995:35).

Beluga whales have been observed near West Dock and the Colville River delta (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996). Results from aerial surveys conducted in late summer/autumn from 1979 to 1994, in late August 1995, and in September/October 1995, recorded belugas from just north of the barrier islands to about 80 miles (129 km) offshore, with most sighted between 37 to 75 miles (60 to 121 km) offshore in water depths over 328 ft (100 m) (Miller et al., 1996:50). During aerial surveys in 1996 conducted by the MMS, a total of 88 beluga sightings and 436 individuals were recorded within the central Alaskan Beaufort Sea (146° to 151° west) (Miller et al., 1997:5-5 to 5-96). Forty-three (49%) of the sightings and 152 (35%) of the individuals observed were sightings within the project area (147° to 150°30' west).

Belugas prey on a wide variety of fish and invertebrates, with diet varying by season and locale (Hazard, 1988:216). In the winter, when most of the population is located offshore along the ice front and within polynyas of the pack ice, fish such as pollock and Arctic cod may be important prey (Lowry, 1985a:8). During the summer, they appear to feed primarily on fish, including salmon, smelt, capelin, eulachon, herring, and Arctic and saffron cod, and on invertebrates such as shrimp, squid, and octopus (Hazard, 1988:211).

6.5.1.2 Ringed Seal

The ringed seal *(Phoca hispida)* (Natchiq) is the smallest and most ice-adapted of the northern seals, and the only species that regularly maintains breathing holes and lairs in and on unbroken shorefast ice during winter (Figure 6.5-1) (Lowry et al., 1985:8). Ringed seals are able to maintain holes, using claws on their front flippers, in shorefast sea ice up to 6.6 ft (2 m) thick (Smith and Stirling, 1975:1300-1302; Kelly, 1988b:61).

Ringed seals are the most numerous and widely distributed of the northern seals and occur in all arctic and subarctic seas where seasonal or permanent ice is present (Kelly, 1988b:60). A large portion of the Alaska population of ringed seals is migratory, wintering on the seasonal ice of the Chukchi Sea and northern and central Bering Sea, and moving north with the retreat of sea ice in spring to the northern Chukchi and Beaufort Seas. In past years, population shifts of ringed seals from the Eastern Beaufort Sea into the Alaskan Beaufort and Chukchi Seas have been observed during winter, however, unusual ice conditions during that year may have contributed to the observed movement and it is unclear if this is a regular occurrence (Kelly, 1988b:60-62). Some juveniles and subadults summer in ice-free nearshore waters of the Chukchi and Beaufort Seas (Frost et al., 1988:5), although most remain with the retreating pack ice (Figure 6.5-1). Conversely, large numbers of adults and subadults overwinter in shorefast and pack ice of the northern Chukchi and Beaufort Seas rather than migrating southward (Kelly, 1988b:80).

Winter density and distribution of ringed seals is determined by ice characteristics, snow cover, water depth, and availability of food resources (Lowry et al., 1985:81-82; Kelly, 1988b:61-62; Green and Johnson, 1983a:11). With the onset of ice formation around November, ringed seals reoccupy the shorefast ice, where they maintain multiple breathing holes and haulout dens through the winter, and establish birth dens in the spring (Smith and Stirling, 1975:1300-1302; Kelly, 1988b:660-62). Breathing holes maintained by ringed seals near Seal Island have been recorded at densities of up to 2.77 holes/square mile (1.07 holes/square km [km^2]) (Green and Johnson, 1983b:12). The availability of suitable sites for birth dens in the pack ice is primarily determined by the presence of pressure ridges. As winter progresses, pressure ridges form at the leads, and snow drifts develop on the lee side of these ice structures. Ringed seals hollow out the drifts to form birthing dens, which may be found in every sizeable drift in some areas (Smith and Stirling, 1975). Although sea ice conditions in the Northstar Unit are variable from year to year, the ice is generally characterized by smooth, shorefast ice (Green and Johnson, 1983b:7). This type of ice is preferred denning habitat in the inshore areas when covered by sufficient snow to accommodate the formation of birth dens (Burns et al., 1982:49; Frost et al., 1988:406).

The number of ringed seals in Alaskan waters is not well documented (Small and DeMaster, 1995:30); however, estimates range from one to six million (Lowry et al., 1985:84). It is probable, based on extrapolation from aerial surveys and on predation estimates for polar bears (Amstrup, 1995:199), that the Alaskan Beaufort Sea portion of the population averages at least 326,500, consisting of an estimated 208,000 in the pack ice and 118,500 in the shorefast ice in winter and spring.

Aerial counts from May and June 1997 indicated an estimate of 2.6 seals/square nautical mile (0.77/km^2) for the area from Barrow to the Canadian border (State of Alaska, 1997:4). Based on aerial counts from 1970 to 1987, during May and June when seals most commonly haul out on the ice, overall observed seal density on the shorefast ice was approximately one seal per every 1.0 to 1.2 square miles (2.5 to 3.1 km^2), with local densities in the shorefast and nearshore pack ice of one seal per every 0.1 to 3.3 square miles (0.3 to 8.5 km^2) (Burns and Harbo, 1972:279; Lowry and Frost, 1981:44). Recent survey data from the central Beaufort Sea, which included the offshore project area, have shown densities of 0.85 to 1.71 seals/square mile (0.33 to 0.66 seals/square kilometer [km^2]) (Frost et al. 1997:3). Inupiat hunters confirm that seals (ringed and bearded) are numerous in the Alaskan Beaufort Sea, including high numbers on the sea ice near Nuiqsut (S. Kanaknana in USDOI, MMS, 1982:6). In general, the observed abundance and density of ringed seals is variable from year to year and location to location, depending to a large degree on snow, ice, and weather conditions during and preceding the survey period (Stirling et al., 1982:4). Observed densities usually have been highest in and near the stamukhi zone between shorefast and pack ice, diminishing both seaward of this zone into the pack ice and shoreward on the landfast ice.

Ringed seals are opportunistic feeders on a wide variety of pelagic as well as epibenthic organisms. They rely heavily on Arctic cod through the winter months (November to April), with a shift toward marine crustaceans (gammarid and hyperiid amphipods, shrimp, euphausiids, mysids, and isopods) in late spring and summer (Lowry et al., 1980:2254; Frost and Lowry, 1984:388-390).

6.5.1.3 Bearded Seal

The bearded seal *(Erignathus barbatus)* (Oogruk) is the largest of the northern seals (Kelly, 1988a:79) and, like the ringed seal, is largely ice-associated. Unlike the ringed seal, however, they rarely maintain breathing holes or birthing dens in shorefast ice. Bearded seals stay mostly within the mobile pack ice, concentrating around its edge (Smith and Stirling, 1975:36).

The bearded seal is circumpolar in distribution, ranging as far north as 85°N over continental shelf water less than 656 ft (200 m) deep (Kelly, 1988a:80). They are also migratory, with most of the Alaskan population following the retreat and advance of the seasonal pack ice north and south across the Chukchi and northern Bering Seas (Nelson et al., 1985:57-58).

The Alaskan Beaufort Sea offers limited habitat for bearded seals in both summer and winter, due primarily to water depths. Because of their epibenthic feeding habits, bearded seals are limited to feeding in water depths of 426 ft (130 m) or less (Nelson et al., 1985:58). In summer, much of the edge of the broken pack ice, a favored habitat for bearded seals (Figure 6.5-1), is over water too deep to permit energy-efficient feeding. As a result, few bearded seals are present in the project area. In general, the summer population density decreases from west to east (Lowry and Frost, 1981:43). Most of the Alaskan Beaufort Sea population stays at or near the edge of the pack ice where it overlaps the continental shelf (USDOC, MMS, 1996:III-B-7), while a smaller number remain in open water or with nearshore ice remnants (Burns et al., 1980:153). The Alaskan Beaufort Sea offers limited feeding habitat during the winter because it freezes. Much of this population is thought to vacate the Alaskan Beaufort Sea with the onset of winter (Lowry and Frost, 1981:43), shifting west into the Chukchi Sea and then south to the northern Bering Sea with the advance of seasonal ice. Small numbers of bearded seals do winter in the Alaskan Beaufort Sea, but generally within the narrow area (stamukhi zone) between the shore-fast and pack ice (Burns and Frost, 1979:22).

Estimates of the total bearded seal population in Alaska waters range from approximately 300,000 to 450,000 (USDOI, MMS, 1996:III-B-7). The winter density of bearded seals in the nearshore Alaskan Beaufort Sea was estimated at about 1 seal per 9.6 square miles (25 km^2) (USDOC, NOAA, 1977:76).

Bearded seals are primarily epibenthic feeders, preying on a wide variety of fish and invertebrate species (Kelly, 1988a:83). Preferred feeding depths in the Alaskan Beaufort Sea are reported to be 82 to 164 ft (25 to 50 m) (Kingsley et al., 1985:1207). Diet varies with age, season, and locale. Major prey items in the Alaskan Beaufort Sea include clams, crabs, shrimp, sculpins, and Arctic cod, augmented by amphipods, isopods, and octopus (Burns and Frost, 1979:60-65; Nelson et al., 1985:59).

6.5.1.4 Spotted Seal

The spotted seal *(Phoca largha)* (Qasigiaq) is a northern form of its close cousin, the harbor seal *(Phoca vitulina)*. Although ice-adapted, they are not nearly as ice-dependent as ringed and bearded seals. In the Alaskan Beaufort Sea, they spend most of their time in nearshore ice-free waters, commonly hauling out on island or mainland shores (Figure 6.5-1).

Spotted seals are seasonal visitors to the southern Alaskan Beaufort Sea from July through about September, where they tend to concentrate in inlets and river mouths. They are found during summer as far east as Herschel Island in the Canadian Beaufort Sea (Quakenbush, 1988:110), although most are found in the Alaskan Beaufort Sea. Concentrations occur on Oarlock Island, near the Colville River Delta, and at the mouth of the Piasuk River in Smith Bay (USDOI, MMS, 1996:Fig. III-B-4). When the ice pack is absent, habitat requirements of spotted seals are similar to harbor seals, and they occupy river mouths and coastal haulout sites such as the Colville River Delta (Quakenbush, 1988:111).

Spotted seals abandon the Alaskan Beaufort Sea in September or early October, moving west into the northern Chukchi Sea and then south through the Chukchi and into the Bering Sea ahead of the winter ice front (Lowry et al., 1994:i). Most of the population winters along the ice front in the Bering Sea (Lowry et al., 1994:5), then follows the retreating ice front north in the spring into the northern Chukchi and Alaskan Beaufort Seas. Some animals, however, remain for the summer in ice-free waters of the Bering and eastern Chukchi Seas (Lowry, 1985:91).

The total number of spotted seals summering in the Alaskan Beaufort Sea is roughly estimated at about 1,000 (USDOI, MMS, 1996:III-B-8). The total Bering Sea population is estimated at between 200,000 and 250,000 (Quakenbush, 1988:111).

Spotted seals prey on a wide array of fish and pelagic crustaceans, with diet varying by season and locale. During winter, they are heavily dependent on fish such as capelin and pollock at the ice front. During spring and summer, young animals rely more on small fish and crustaceans (shrimp, euphausiids, crabs, amphipods), with adults consuming larger fish species, crustaceans, squid, and octopus (Lowry, 1985b:93).

6.5.1.5 Polar Bear

Polar bears *(Ursus maritimus)* (Nanuq) are wide-ranging predators present year-round over most of the Alaskan Beaufort Sea region. They are highly ice-adapted and strongly ice-dependent. The polar bear is circumpolar in distribution, ranging seasonally in Alaska waters, from the central Bering Sea to 88°N latitude (Amstrup, 1995:45).

The Southern Beaufort Sea population ranges from Cape Bathurst in Canada into the northern Chukchi Sea and appears to be relatively discrete (Amstrup, 1995:283). The population in the Alaskan Beaufort Sea shifts from north to south and back following the advance and retreat of sea ice (Amstrup, 1995:284). In winter, most of the population is concentrated along the shear zone between the multi-year pack ice and the shorefast ice. In summer, most of the population shifts north to remain at or near the edge of the pack ice (Taylor, 1982:117), although some individuals may remain on shore through the summer (Lentfer, 1985:28).

Polar bears range from at least 37.2 miles (60 km) inland to over 186.4 miles (300 km) offshore in the Alaskan Beaufort Sea, with individual bears known to range up to 466 miles (750 km) from east to west and 233 miles (375 km) from north to south (Amstrup et al., 1986:91; 1995:124-126). These bears are most active from October through December and during May and June. They do little wandering from January through March and during September (Amstrup, 1995:82).

Polar bears have been observed congregating on the barrier islands in the fall and winter because of available food and favorable environmental conditions. Polar bears will occasionally feed on bowhead whale carcasses nearby Cross Island and on Barter Island to the east. In a November 1996 survey conducted by the U.S. Geological Survey, 28 polar bears were observed near a bowhead whale carcass on Cross Island, and approximately 11 polar bears were within a 2-mile (3.2 km) radius of a bowhead whale carcass near the Village of Kaktovik on Barter Island (Kalxdorff, 1998:5). In October 1998, 47 polar bears were observed on barrier islands and the mainland from Prudhoe Bay to the Canadian border (G. Durner - Pers. Comm., 1998:3).

Satellite tracking of radio tagged polar bears between 1985 and 1997 within a 5- to 20-mile (8 to 32 km) radius of Seal Island resulted in two polar bear observations within 5 miles (8 km), 24 within 10 miles (16 km), 66 within 15 miles (24 km), and 187 within 20 miles (32 km) of the island (G. Durner - Pers. Comm., 1998:2). Since 1967, personnel involved with polar bear research using conventional methods, have sighted 5 bears within 5 miles (8 km), 36 within 10 miles (16 km), 60 within 15 miles (24 km), and 109 within 20 miles (32 km) of Seal Island (G. Durner - Pers. Comm., 1998:3).

The world population for this species probably exceeds 20,000, with estimates of the Alaska population ranging from 3,000 to 5,000 (USDOI, FWS, 1995:xii). The Southern Beaufort Sea population is estimated at about 1,500 to 1,800 (Amstrup, 1995:160, 215), with an average density of about one bear per 38.6 to 77.2 square miles (100 to 200 km^2) (Amstrup et al., 1986:244; Armstrup and DeMaster, 1988:43). Somewhat higher densities of one bear per 30 to 50 square miles (78 to 130 km^2) are estimated within the nearshore Alaskan Beaufort Sea (USDOI, MMS, 1996:III-9).

Polar bear numbers declined toward the end of the trophy hunting era (1958 to 1972), but have recovered since passage of the U.S. Marine Mammal Protection Act in 1972. Inupiat hunters have noticed that there are more polar bears than there once were (A. Ahkiviana - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:25-26). Based on long-term population data from 1982 to 1992, the southern Beaufort Sea polar bear population growth rate was 2.4% annually (Amstrup, 1995:230). Because the U.S. Fish and Wildlife Service (USFWS) believes this population is near the carrying capacity of the environment, the growth rate is expected to slow or stabilize.

Polar bears breed from late March through May (USDOI, FWS, 1995:xii), with cubs born in late December or early January (Amstrup, 1995:23). Male polar bears, as well as non-pregnant females and females with young, remain active throughout the winter. Pregnant females excavate dens in drifted snow, usually by late November. Of 90 polar bear dens categorized by Amstrup and Gardner (1994:1), 48 (53%) occurred on drifting ice, 38 (42%) on land, and 4 (4%) on land-fast ice (Figure 6.5-1). The recent trend towards an increase of onshore denning in the Canadian Beaufort Sea (Stirling et al. 1988:ii; Stirling and Andriashek, 1992:363) and in the Alaskan Beaufort Sea (Amstrup, 1995:292) may be the result of denning bears being relatively faithful to denning substrate and limited hunting in the early to mid-1900s, which may have prevented re-establishment of land denning until recently (Amstrup and Gardner, 1994:1). This suggests that denning polar bears are sensitive to disturbance and there should be concern for potential disruptions (Amstrup, 1995:292). The highest occurrence of dens on land is found east of the project area, within the Arctic National Wildlife Refuge (ANWR) and into Canada. Other known denning areas along the Alaskan Beaufort Sea coast are on barrier islands (Pingok, Cottle, Thetis, Flaxman), the Colville River Delta, and other stream mouths and lagoons (USDOI, FWS, 1995:25, 27-28). Polar bears are known to den near the project area. Polar bears have denned near the Kuparuk River Delta area (Amstrup - Pers. Comm., 1998:1). Polar bear maternity den records within a 5- to 20-mile (8 to 32 km) radius of Seal Island show no den sites within 10 miles (16 km), three within 15 miles (24 km), and seven within 20 miles (32 km) (G. Durner - Pers. Comm., 1998:2). Pregnant females tend to return to the same general area on either land or pack ice for denning, although not to the same particular location (Amstrup, 1995:92).

Females normally give birth to two cubs (Ramsay and Stirling, 1988:615) in late December or early January (Amstrup, 1995:23). Cubs remain with the mother in the den until late March or early April. After emergence from the den, cubs normally nurse and remain with the mother for about 3 years. About 140 females of the Alaskan Beaufort Sea polar bear population reproduce each year (USDOI, FWS, 1995:22), resulting in a reproduction rate of 0.23 to 0.32 cubs per female per year overall (Amstrup and DeMaster, 1988:47).

Polar bears prey primarily on ringed seals, although they will take bearded seals, spotted seals, young walrus, beluga whales confined in ice, and will also feed on the carcasses of any of these animals (Amstrup and DeMaster, 1988:44; USDOI, FWS, 1995:XIII-XIV; Kalxdorff, 1998:18). Ringed seals are taken by stalking on the open ice, at breathing holes and haulout dens, and in birth dens (Stirling et al., 1975:6).

6.5.2 Environmental Consequences

The following section describes the potential impacts of the project alternatives on marine mammals. Discussion of impacts is organized based on project alternatives described in Chapter 4. A discussion of the relevant issues to marine mammals is presented in the alternatives sections as they are related to project phases (construction, operation, maintenance, abandonment) and project components (gravel mining, island reconstruction, onshore pipeline construction, offshore pipeline construction, offshore facilities construction). Impacts to marine mammals are the same for Alternatives 2, 3, 4, and 5. Therefore, these alternatives are discussed together and summarized in Table 6.5-2.

6.5.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative, consequently, there would be no impacts to marine mammals. The natural variability in population levels and habitat of marine mammals in the Alaskan Beaufort Sea would be undisturbed by a No Action Alternative.

6.5.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Gravel mining activities from development of the Kuparuk River Delta mine, such as blasting and movement of heavy equipment for loading and transporting gravel, would create noise and disturbance. Much of the noise and activity associated with mining and gravel hauling would be similar to other industrial activities, such as snow removal, truck traffic, and road maintenance, that already occur periodically in the project area. Beluga whales would not be affected by gravel mining activities as they are not in this area during winter (Hazard, 1988:200). Ringed and bearded seals would not be affected by gravel mining on the Kuparuk River Delta because this area is not winter seal habitat due to the presence of bottom-fast ice (Frost and Lowry, 1984:387). Spotted seals would not be present in the Alaskan Beaufort Sea during gravel mining activities, therefore they would not be impacted (Lowry et al., 1994:i). No impacts to whales and seals are expected.

Disturbance to female polar bears at maternity dens could result in either abandonment of cubs or premature exposure of cubs (Amstrup, 1993). Polar bears that den onshore require a greater topographic relief than that found in this area of the Alaska Coastal Plain, since they need deep, compacted snow drifts from which they can excavate snow dens (Amstrup and DeMaster:

Table 6.5-2 (page 1 of 2)

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1988:45). Polar bears have denned near the Kuparuk River Delta area (S. Amstrup - Pers. Comm., 1998:1). Polar bear denning habitat on the Arctic Coastal Plain includes banks which are greater than or equal to 5 ft (1.5 m) high. Consequently, denning polar bears are possible and could occur near the mine site. Should denning polar bears be disrupted near the mine site, the impact would be considered minor.

Offshore ice road construction, pipeline construction and island reconstruction are not expected to affect spotted seals and beluga whales because they are not present within the project area during winter, when construction is planned (Hazard, 1988:200). A large portion of the Alaska population of ringed seals is migratory, wintering on the seasonal ice of the Chukchi Sea and northern and central Bering Sea, and moving north with the retreat of sea ice in spring to the northern Chukchi and Beaufort Seas (Frost and Lowry, 1984:387). Impacts to the ringed seal from ice road construction, offshore pipeline construction, and island reconstruction, are considered minor and primarily related to temporary displacement due to noise and are discussed in detail in Chapter 9. Based on data from aerial counts between Point Barrow and the Canadian border (State of Alaska, 1997:4) it was estimated that less than 35 ringed seals would be present in the offshore pipeline corridor. Based on these densities, up to 12 ringed seals may be displaced by noise and activity during construction and installation of facilities on Seal Island. Due to the low numbers of bearded seals in the nearshore Alaskan Beaufort Sea during winter (Lowry and Frost, 1981), the impact of disturbance from noise of pipeline and ice road construction on this species is likely to be localized, temporary, and negligible. Since offshore pipeline construction activities and island reconstruction will occur during the winter at a time when beluga whales and seals are not in the project area, no impact to these species are anticipated.

Polar bears may either avoid or be attracted to construction activities on the island, offshore pipeline construction, and ice road construction, depending upon the circumstances and temperament of individual bears (Amstrup et al., 1986:242). Attraction of polar bears would likely result in increased risk of confrontations with humans and some bears could be killed. Due to the relatively small southern Beaufort Sea polar bear population of (approximately 1,800), their low reproductive potential, and low density (Amstrup et al., 1986:224; Amstrup and DeMaster, 1988:43), the harvest quota set by the NSB/Inuvailuit Game Council management agreement for the Southern Beaufort Sea population aims for strict conservation. The agreement establishes sustainable harvest quotas based upon an estimate of population size, modeling of sustainable yield rates for female polar bears, and information regarding the sex ratio of the harvest (Treseder and Carpenter, 1989:4; Nageak et al., 1991:341). Although construction activities could result in attraction and some mortality of bears, this is expected to occur infrequently and would not affect polar bear populations. This impact is considered to be minor.

Construction activities, such as ice road construction, pile installation and drilling, would create noise and vibration that could impact beluga whales, ringed, spotted, and bearded seals and polar bears. Potential impacts from noise on these species, such as avoidance, are considered minor and discussed in Chapter 9.

Operation Impacts: Operations on Seal Island would take place year-round over the expected 15-year life of the project. These operations are not expected to create additional open water leads due to the design parameters of the island that would allow normal ice patterns to form in the vicinity of the island. However, should an open water area form around Seal Island, seals near the area can be expected to utilize the open water as a breathing hole, which may subsequently attract polar bears. Entrapment of seals in the open water lead could occur, although this would be considered a minor impact to the ringed seals.

Long-term marine mammal habitat is not expected to be created as a result of construction of Seal Island. Increased numbers of fish at Seal Island (Section 6.4.2.2) may attract seals to the island. Spotted seals may use the island as a haulout site when they are present in the Alaskan Beaufort Sea from July through September (Quakenbush, 1988:11). However, given that spotted seals normally congregate at river mouths, it is unlikely that they would use Seal Island (Quakenbush, 1988:110). Ringed and bearded seals are ice-adapted and are not expected to be attracted to Seal Island as either a feeding or haulout site (Lowry et al., 1985:81-82; Kelly, 1988b:61-62; Green and Johnson, 1983a:11; Smith and Stirling, 1975:36). The attraction of seals to Seal Island as a result of the creation of a long-term habitat is considered to be minor.

Marine mammals primarily would be affected through increased levels of noise from gas-fired turbines and generators, and by ship and helicopter traffic to and from the island for routine operations. Transportation of personnel and supplies during routine island operations would include the use of trucks on ice roads during winter (November to April), helicopters during broken ice seasons (May/June and October/November), and barges during open water (May/June to September/October). Noise effects from offshore sources on marine mammals such as ringed and bearded seals and beluga whales would be limited to behavioral reactions and possible avoidance of Seal Island. Polar bears may either avoid or be attracted to operational activities depending on the circumstances and temperament of the individual bears (the same would be true for pipeline and ice road operation activities). Potential noise-related impacts to marine mammals during the operations phase are minor and are discussed further in Chapter 9.

Potential effects of oil to marine mammals could include direct mortality from oil contact and loss of thermoregulation (ability to maintain a constant internal body temperature independent from environmental temperature), oil toxicity, chronic physiological or behavioral changes, destruction of food organisms, and habitat destruction. Effects of oil on beluga whales have not been well documented and are subject to speculation (Geraci, 1990:197-168). Observations of other cetacean species during an oil spill have not demonstrated a tendency to avoid oil on the water (Harvey and Dahlheim, 1994:260-263); therefore, if oil were present, belugas would be affected. The effects of oil on ringed seal populations are unknown; however, a number of studies have investigated the effects of oil on individual ringed seals. Controlled experiments on three ringed seals in a laboratory holding pen showed that exposure to oil-contaminated water immediately caused the animals to shake vigorously, and all seals died within 71 minutes (Geraci and Smith, 1977:402). Subsequent necropsy (after death examination) did not link the cause of death directly to oil exposure but was probably related to stress. Six ringed seals in natural seawater holding pens in the Arctic showed swollen nictitating (eye) membranes and, in one case, corneal (eye) erosions, but all seals had recovered by the fourth day after exposure to oil (Geraci and Smith, 1977:403).

Investigations of the effects of oil on other seal species have demonstrated conclusively the toxic effects of contact with crude oil. Studies of the effects of oil on harbor seals during and after the *Exxon Valdez* oil spill have shown that harbor seals apparently exhibited no avoidance of oil, either in the water or at haulout sites (Frost and Lowry, 1994:i; Frost et al., 1994:109). Seals exposed to fresh oil or vapors suffered eye damage, skin irritation, disorientation, hemorrhage of internal organs, conjunctivitis, and brain lesions, and it was estimated that hundreds of seals died after contacting oil (Frost and Lowry, 1994:xi, 46; Spraker et al. 1994:304-305). Mortality of pups was estimated at 23% to 26%, and adult mortality was 36%. Data from aerial surveys conducted during the molt in 1983, 1984, and 1989 through 1992 indicate that counts of harbor seals decreased more in oiled areas of Prince William Sound following the *Exxon Valdez* oil spill than in unoiled areas (Frost and Lowry, 1994:40). However, declines in several of the geographic populations throughout Alaska, in particular near the Kodiak Archipelago and in Prince William Sound, have been noted over the past several years (prior to the *Exxon Valdez* oil spill). A major decline of 85% of the harbor seal population at Tugidak Island, located in the Gulf of Alaska to the South of Kodiak, was recorded between 1976 and 1988 (Pitcher, 1990:121)

The effects of oil on bearded and spotted seals have not been well documented, but they are likely to be similar to those for ringed and harbor seals. An oil spill could also affect bearded seals through impacts on their food web. Bearded seals might be more prone to consumption of prey contaminated from oil spills due to their reliance on benthic and epibenthic prey, which are generally limited in terms of mobility. These seals also might suffer population declines or dislocation if local prey availability is reduced.

Polar bears may suffer hair loss due to oiling of the fur (Derocher and Stirling, 1991:56) resulting in severe cold stress (Oritsland et al., 1981:3). A doubling of the metabolic rate has been observed in polar bears after exposure to oil, as well as an increase in core body temperature reminiscent of fever in humans (Oritsland et al., 1981:3). The increased body temperature may be compensation for a reduction in fur insulation (Hurst et al., 1982:263).

Controlled experiments on three polar bears exposed to oil resulted in observed tremors and weight loss, followed by kidney failure and eventual death (Engelhardt, 1981:170; Oritsland et al., 1981:6). Other serious effects included changes in the liver and brain, bone marrow depletion, ulcers of the gastrointestinal tract, and inflammation of lungs and nasal passages (Oritsland et al., 1981:4). During these experiments, polar bears showed no avoidance of oil in water, and it was concluded that polar bears contacting oil would be contaminated to a large extent (Oritsland et al., 1981:55). Oil contamination could have severe consequences to polar bears based on these experiments. Lentfer (1990:15) concluded that a bear that has encountered contamination if not rehabilitated will suffer lethal effects. He noted that the effects of a large spill or multiple small spills on polar bear habitat are not well understood. The lingering effects of spilled oil in or near denning areas may cause the loss of litters, aborted fetuses, or selection of denning areas in less favorable (i.e., more vulnerable) habitats (Bright, 1998:2). Potential impacts of oil to marine mammals are discussed in Chapter 8.

Maintenance Impacts: Both planned and unplanned maintenance activities associated with operations would take place year round over the expected 15-year life of the project. Planned maintenance of offshore pipelines would not entail excavation and, therefore, impacts to marine mammals are considered negligible. Unplanned maintenance of offshore pipelines during normal operations that requires excavation would cause limited disturbances similar to those created during construction. The degree of impact would vary depending on the nature of the problem, season, and approach used to uncover/rebury the pipe and to perform repairs. During the open water season, the magnitude of effects on nearshore species such as the spotted seal would vary depending on the extent of required repairs and the method used to excavate the pipeline and conduct repairs. These impacts are expected to be short-term and limited and, thus, have a minor impact on marine mammals.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to marine mammals would be expected to be similar or possibly greater to those generated during construction and would be considered negligible to minor.

6.5.3 Summary of Environmental Consequences

No significant adverse impacts were identified for marine mammals from development of the project (bowhead whales, which are an endangered species, are discussed in Section 6.9 - Threatened and Endangered Species) with the possible exception of potential impacts to polar bears from a large oil spill (discussed in Section 8.7.2.3).

Alternative 1 results in no impact to marine mammal resources in the Alaskan Beaufort Sea. Under Alternative 1 - No Action Alternative, the existing population would continue to experience fluctuations in populations levels with a range of natural variation as are occurring at the present time.

The development of Alternatives 2, 3, 4, or 5 would result in some minor impacts to ringed seals and polar bears during the stable ice period (e.g., noise and construction disturbance on ringed seals). Polar bears may be either attracted or displaced by activity on the ice, but impacts are considered minor. In addition, impacts to denning polar bears are not expected. Beluga whales are only present during the open water period in fall, and no impacts are anticipated.

Under Alternatives 2, 3, 4, and 5, development of Seal Island and construction of the offshore pipeline could result in direct, short-term impacts from disturbance and displacement of seals from the vicinity of Seal Island or the ice road traffic and disturbance or attraction of polar bears to the island. No impacts to spotted seals are expected, and only negligible impacts to bearded seals are anticipated. No long-term adverse impacts to marine mammals from planned construction, operation, or maintenance activities were identified.

The abandonment of Seal Island would not create any additional habitat for marine mammals or affect the use of the area by marine mammals.

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6.6 COASTAL VEGETATION AND INVERTEBRATES

6.6.1 Affected Environment

The coastal vegetation and wetlands of the Arctic Coastal Plain are important components of the ecosystem as they support a large food web of terrestrial and aquatic invertebrates, provide habitat for resident and migratory wildlife species, and regulate the regional hydrologic regime and maintain water quality. The coastal vegetation and variety of invertebrates present on the Arctic Coastal Plain are strongly influenced by land features, climate, soil composition, surface water, and microtopography, which also determines the composition of several tundra communities.

6.6.1.1 Setting

Alaska's Arctic Coastal Plain is covered by low-growing tundra vegetation and innumerable ponds and lakes, but no trees. Saturated soils, severe weather conditions, and a short growing season contribute to low species diversity and slow growth relative to areas south of the Brooks Range. Because of cold soil temperatures and the short growing season, decomposition is slow, and energy and nutrients tend to remain bound up as dead organic matter. Net primary productivity, nutrient release, and energy flow rates increase with site moisture. Thus, for the Arctic Coastal Plain, wetter sites generally will make a greater contribution to overall ecosystem productivity (Lawson et al., 1978:x).

The onshore portion of the alternative pipeline routes are located within the region of the Arctic Coastal Plain referred to as the rolling thaw-lake plain and the flat thaw-lake plain (Walker and Acevedo, 1987:1) (Section 5.3.1). These areas are generally characterized as mostly flat and wet with numerous thaw-lakes, polygon-patterned and non-patterned ground, and underlain by shallow permafrost (Walker et al., 1980:14; Walker, 1985:5). The distribution of vegetation is influenced by climate, soils, surface water, and microtopography. Associated invertebrate communities are correlated with water regime and vegetation and appear in a brief burst of activity during warm summer weather while the vegetation is growing.

Climate is a major factor in distribution of vegetation communities. Summer temperatures along the Beaufort Sea coast are generally cool, with a rather steep temperature gradient going inland. In July, temperatures can increase from a mean of 39°F (4°C) at the coast to 46°F (8°C) at inland areas (Walker, 1985:9). This is believed to be responsible for a coastal band of vegetation that has fewer shrubs, limited tussock-type sedges, and reduced moss and lichen growth (Walker, 1985:91; Walker and Acevedo, 1987:12).

Most of the region has hydric (wet) soils as a result of shallow permafrost and seasonal flooding. Saturated soils above the permafrost layer during the growing season result in anaerobic (no oxygen) conditions which favor the growth of wetland vegetation. Anaerobic conditions and low temperatures also impede decomposition of organic material, resulting in the accumulation of plant material as peat or muck. Soils are mostly acidic across the coastal plain, except in the area around the Sagavanirktok River Delta where alkaline silt (loess) is blown inland from the delta by prevailing northeast winds, creating alkaline soils (Walker, 1985:119).

Most of the onshore project area is wetlands. Lakes, ponds, and streams make up 25% of the onshore project area (Figure 6.6-1). Drained or partially-drained lake basins are also characteristic of the onshore project area and develop into ecologically diverse wetland complexes of shallow water and flooded and wet tundra communities (Bergman et al., 1977:20-23).

Microtopography (small surface features) created by ice-wedge polygons results in a mosaic of micro-habitats, each with distinct vegetation (Walker and Acevedo, 1987:11). Three types of patterned ground cover most of the region: low-centered polygons, high-centered polygons, and disjunct polygon rims. The most common type of polygon in the project area is low-centered polygons, which have wet centers and moist raised rims. High-centered polygons with relatively higher centers and the somewhat well-drained or "moist" tundra are less common in the project area (Walker, 1985:41).

6.6.1.2 Land Cover Mapping

Vegetation of the general Prudhoe Bay region has been mapped in association with soils and land forms in relatively broad categories, based on features interpreted from aerial photographs (Webber and Walker, 1975:81-91; Walker et al., 1980:24-64; BPXA, 1992:Map 2). The original maps were refined and modified to produce a vegetation map of the project area (Figure 6.6-1).

Wetlands within the project area have been mapped by the USFWS, National Wetlands Inventory (NWI) and these maps were used in the southeast portion of the project area, which was not covered by the above mapping efforts (USDOI, FWS, 1991:Maps 1-5). These maps were developed using a slightly different classification system which provides less detail than the project area maps based on Walker et al. (1980:24).

6.6.1.3 Terrestrial Communities

There are four major tundra vegetation communities in the onshore project area, generally defined by moisture regimes: dry, moist, wet, and aquatic (Table 6.6-1). Less common and sparsely vegetated types include sand dunes, barrier islands, mud flats, and beaches. Lakes, ponds, and streams also may have little vegetation, but are important habitat for invertebrate species. Invertebrate species vary with the moisture regime and are associated with specific vegetation types.

Many of the dominant plant species, such as *Carex aquatilis* (water sedge) and *Eriophorum* sp. (cottongrasses), have a wide ecological range and dominate many of the vegetation communities, differing only in the degree of water saturation they prefer (Walker, 1985:104). These two species, plus *Dryas integrifolia* (entire-leaf

Figure 6.6-1a (Page 1 of 2)

Figure 6.6-1a (Page 2 of 2)

Figure 6.6-1b (Page 1 of 2)

Figure 6.6-1b (Page 2 of 2)

Figure 6.6-1c (Page 1 of 2)

Figure 6.6-1c (Page 2 of 2)

Table 6.6-1 (Page 1 of 1)

mountain avens), make up approximately 78% of the vascular plant cover of the project area (Walker, 1985:104).

The vegetation communities and associated invertebrate species are closely linked and largely determine which species of birds use which tundra types. Insects are the most abundant invertebrates, followed by mites (Acarina), spiders (Araneae), and springtails (Collembola). Terrestrial invertebrates are integrated into arctic systems and play many biological roles, including decomposition and predation. The occurrence of invertebrates in the Arctic is dependent on the effects of temperature, daylight, insolation, and moisture (Danks, 1992:161). In addition, invertebrates in the Arctic must make physiological adaptations to low winter temperatures, short growth and reproduction seasons, low temperatures during the growing season, low primary production, and weakness of photoperiodic cues (MacLean, 1975:269).

Dry Tundra: Dry tundra communities occur on well-drained mineral soils or gravely soils and cover approximately 2% of the Prudhoe Bay oil fields (Walker et al., 1980:25) and less than 1% of the Arctic Coastal Plain between the Colville and Canning Rivers (Beechy Point Quadrangle) (Walker and Acevedo, 1987:49). As shown on Figure 6.6-1, these percentages appear to be approximately correct for the project area (vegetation types 1, 2 and 6). Vegetation typically consists of prostrate shrubs (*Salix* sp. and *Dryas integrifolia*), herbaceous species such as *Oxytropis nigrescens* (black oxytrope) and *Saxifraga oppositifolia* (purple mountain saxifrage), and *Carex* sp. (sedges) (Walker et al., 1980:25). Dry tundra communities are found on the sides of pingos, elevated and exposed windblown ridges, river bluffs, high-centered polygons, and rims of drained lake basins (Walker, 1985:21).

Dry tundra communities in the project area exposed to saltwater include dry coastal bluffs and beaches dominated by *Cochlearia officinalis* (common scurvy grass) and *Puccinellia phryganodes* (creeping alkali grass). In areas subject to inundation by salt water, *Dryas integrifolia* is killed, while *Braya purpurasens* (purple braya) and *Puccinellia andersonii* (shining alkali grass) remain alive (Walker et al., 1980:30). Dry tundra communities are described under the NWI classification system as palustrine scrub-shrub wetlands due to their saturated soils and the presence of permafrost.

Invertebrates of dry tundra in the project area include larvae of craneflies (Tipuilidae) and midges (Chironomidae) (Truett and Kertell, 1990:15).

Moist Tundra: Moist tundra areas are typically drained of standing surface water soon after snowmelt, but small areas of water remain in depressions. It is found in poorly-drained, patterned ground of high-centered polygons or in strangmoors, areas of discontinuous ridges and low wet areas. Expanses of unpatterned moist tundra also occur in areas of drained-lake basins (Walker, 1985:24). This vegetation type consists of graminoid meadows of either tussock-forming *Eriophorum* sp. or non-tussock *Carex* sp., and dwarf shrubs (Walker, 1985:25). Common species are *Eriphorium angustifolia* (thinleaf cottongrass), *Carex aquatilis*, *Carex bigelowii* (Bigelow's sedge), *Dupontia fisherii* (Fisher's tundra grass), *Alopecurus geniculatus* (alpine foxtail), and dwarf shrubs such as *Dryas integrifolia* and *Salix* sp. (Walker, 1985:24). Moist tundra communities are typically classified as palustrine emergent and scrub-shrub wetlands under the NWI classification system.

Invertebrates in standing water habitats early in the year are dominated by midges, other dipterans, oligochaetes, steroptera, coleoptera and gastropods (OIW, 1979:32). Following snowmelt, moist tundra areas become drier and are similar to dry tundra with regard to invertebrate species composition.

Wet Tundra: Wet tundra is the dominant vegetation community on the Arctic Coastal Plain and is widespread in the onshore portion of the project area. It is found in poorly-drained, patterned ground of low-centered polygons or strangmoor, and unpatterned areas in drained-lake basins (Walker et al., 1980:27). Wet tundra sites typically have standing water in early summer, which drains by mid-summer in most years (Walker, 1985:26). Wet tundra also occurs in the onshore project area at microsites, such as troughs around high-centered polygons, between hummocks in moist areas, and along lake margins (Walker et al., 1980:27).

Acidic wet sedge tundra is composed primarily of *Carex aquatilis* with minor amounts of other sedges, such as *Carex saxitalis* (russet sedge), *Carex rariflora* (loose-flowered sedge), *Carex rotundifolia* (round-fruit sedge), and *Eriophorum angustifolia.* Only a few forbs or shrub species (*Salix* sp.) are found in wet tundra communities (Walker et al., 1980:30; Walker, 1985:26).

These communities are classified as palustrine emergent wetlands or emergent and scrub-shrub wetland under the NWI classification system.

Invertebrate species present in wet tundra areas include: chironomids, calanoid copepods, daphnids, nemourids, and physids, as well as oligochaete worms, snails, mites, and turbellarians.

Aquatic Tundra: Aquatic tundra communities consist of vegetation at sites with a continuous water cover throughout most summers (Walker et al., 1980:28). This vegetation type most often occurs at the margins of lakes and ponds, and in partially-drained lake basins. Plant species in aquatic tundra are controlled by water depth (Walker, 1985:28). In shallow water less than 4 inches (10 cm) deep, *Carex aquatilis* dominates, with lesser amounts of other sedges, such as *Eriophorum angustifolium* and *E. scheuchzeri* (Scheuchzer's cottongrass). Slightly deeper water, up to 12 inches (30 cm) deep, supports stands of *Carex aquatilis* with only a few aquatic forbs species, such as *Caltha palustris* (marsh marigold) and *Utricularia vulgaris* (blatterwort) (Walker, 1985:28). In deeper water up to 3.3 ft (1 m) deep, *Arctophila fulva* (pendant grass) is the dominant species and typically is found along the margins of lakes or large ponds, especially in partially-drained lake basins. In the larger, oriented thaw lakes that do not have protected embayments, *Arctophila fulva* is less common (Walker, 1985:29). These wetlands are classified as palustrine emergent wetlands under the NWI classification system.

Invertebrate species composition in aquatic tundra areas is similar to that found in ponds and lakes (Section 6.6.1.4). Those most associated with emergent plants are caddisflies (*Limnephilus* and *Micrasem*a sp.), the stonefly (*Nemoura* sp.), predaceous dytiscid beetles (*Agabus* and *Hydroporus* sp.), chironomids (*Corynoneura*, *Paraanytarsus*, and *Trichotanypus* sp.), mites (*Libertia* sp.), enchytraeid worms (*Propappus* sp.), snails (*Physa* sp.), and turbellid worms (West and Snyder-Conn, 1987:11; Hobbie and Pendleton, 1984:27).

Wet Saline Tundra: Saline tundra (salt marsh) communities are less common, limited in size, and mainly found in low-lying areas along the coast, such as the mouths of streams or rivers and in shallow protected areas adjacent to estuaries and lagoons (Walker et al., 1980:30). These salt-affected communities are composed of plant species found almost exclusively in these coastal habitats. *Carex subspathacea* (Hoppner's sedge), *Carex ramenskii* (Ramensk's sedge), *Carex urcina* (bear sedge), and *Puccinellia phryganoides*, and salt-tolerant forbs such as *Stellaria humifusa* (low starwort) and *Cochlearia officinalis* are found in saline tundra.

These relatively productive communities are limited in distribution on a regional basis, but are heavily used by some shorebird species during brood-rearing and post-breeding periods, and by brood-rearing, staging, and migrating waterfowl (TERA, 1994:30). Large expanses of saline tundra occur on the deltas and low-lying areas of the Sagavanirktok, Kuparuk, and Putuligayuk Rivers and in drained-lake basins adjacent to the coast, including areas near Point McIntyre and Point Storkersen (USDOI, FWS, 1991:Map 1). Saline tundra communities are classified as estuarine emergent wetlands under the NWI classification. Estuarine systems include all the semi-enclosed nearshore waters within the barrier island/lagoon systems and adjacent saline tundra. Estuarine intertidal wetlands may be either vegetated (with salt-tolerant grasses and forbs) or unvegetated flats (USDOI, FWS, 1991:10).

Species of invertebrates present in wet saline tundra include zooplankton (cladocerans and copepods), pelecypods, priapulids, polychaetes, tunicates, isopods, mysids, and amphipods.

Sand Dunes, Barrier Islands, Mud Flats, and Beaches: Another dry soil community is found in sand dunes. Sand dune communities occur in small areas at the mouths of the Kuparuk and Sagavanirktok Rivers and typically consist of *Elymus arenaria* (sea lyme-grass) and *Dupontia fisherii.* More stable dunes support a diverse flora of grasses and small forbs adapted to very dry conditions, and include *Androsace chamaejasme* (sweet-flowered rock jasmine), *Artemisia borealis* (arctic wormwood), and *Festuca* sp. (fescue grasses) (Walker, 1985:35).

The low-lying barrier islands located offshore are composed primarily of gravel and sand, and are subject to periodic inundation with saltwater. They support a sparse vegetative cover of *Elymus arenaria* and salt-tolerant forbs such as *Mertensia maritima* (oysterleaf) and *Honckenya peploides* (sea-beach sandwort) (Schamel, 1978:55). These areas are classified as estuarine wetlands under the NWI classification system (USDOI, FWS, 1991:14).

Invertebrates which occupy the mudflats and lower beach habitats include several species of clams, worms, and snails. Marine zooplankton that concentrate along the beaches of the barrier islands and along the outer coast are an important food source for some juvenile birds (Johnson and Richardson, 1981:286; Connors, 1984:407).

6.6.1.4 Aquatic Habitats

Approximately 99% of the onshore project area is wetland and aquatic habitat, with the remaining habitat being dry tundra (Bergman et al., 1977:23). Approximately 25% of the onshore project area is lakes, ponds, and streams. Drained or partially-drained lake basins, which make up approximately 17% of the wetland habitats, are also characteristic of the onshore project area and develop into ecologically diverse wetland complexes of shallow water and flooded and wet tundra communities (Bergman et al., 1977:20-23). Aquatic grass tundra, dominated by *Arctophila fulva*, occurs along the shoreline of many lakes classified as lacustrine (USDOI, FWS, 1991:8).

In arctic ponds and lakes, the phytoplankton is comprised of numerous species of nanoplankton (mostly very small chrysophytes and crytophytes) which are heavily grazed by the common zooplankton species (primarily crustaceans) (Hobbie and Pendleton, 1984:19). These aquatic habitats and the wet portions of tundra communities in the project area also support large populations of larger invertebrate species (macroinvertebrates), which provide food for waterfowl and shorebirds (Bergman et al., 1977:27). Bottom-dwelling invertebrates are more abundant than free-swimming forms (Bergman et al., 1977:20-23). Most freshwater aquatic habitats in the project areas do not support fish populations, because they freeze to the bottom during winter. Aquatic invertebrates are the main source of animal protein for diving birds, especially females and young during brood-rearing.

Freshwater rivers/streams within the project area include the Sagavanirktok, Putuligayuk, and Kuparuk Rivers, classified under the NWI classification as riverine systems. The larger rivers are generally unvegetated and do not freeze completely in deep areas. Small, slow-moving tundra streams have emergent vegetation such as *Arctophila fulva* along their edges (Bergman et al., 1977:18-20), but larger rivers are unvegetated. The unvegetated or partially-vegetated river bars and flats are also considered riverine (USDOI, FWS, 1991:1). Vegetation on gravel bars consists of herbs (*Lupinus arcticus, Hedysarum mackenzii, Artemisia tilesii, Crepis nana, Epilobium* sp., *Taraxacum lacerum, Astragalus* sp.), horsetails (*Equisetum arvense*), rushes (*Juncus arcticus*), shrubs (*Salix* sp., *Alnus crispus*), and grasses (*Agropyron macrourum, Deschampsia caespitosa*) (OIW, 1979:55).

Trichoptera, ephemeroptera, plecoptera, and chironomids are the most common invertebrates in rivers and streams (OIW, 1979:32).

6.6.2 Environmental Consequences

The following section describes the potential impacts of each project alternative on coastal vegetation and invertebrates. Discussion of impacts is organized based on project alternatives described in Chapter 4. A discussion of the relevant issues to coastal vegetation and invertebrates is presented in the alternatives section as they are related to project phases (construction, operation, maintenance, abandonment) and project components (gravel mining, island reconstruction, onshore pipeline construction, offshore pipeline construction, offshore facilities construction). Impacts to coastal vegetation and invertebrates are similar for Alternatives 2, 3, 4, and 5: only the amount of the habitat affected differs among alternatives as a result of different landfall locations. Therefore, potential impacts to coastal vegetation and invertebrates from Alternatives 2, 3, 4, and 5 are discussed together, with the amount of affected habitat delineated and summarized in Table 6.6-2.

6.6.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative, consequently, there would be no impacts to coastal vegetation and invertebrates. The vegetation communities and wetlands in the project area would continue to experience gradual change from natural processes such as the draining and filling of lake basins, coastal erosion, and the thaw lake cycle.

6.6.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Development of the proposed gravel mine site at the mouth of the Kuparuk River would affect approximately 35 acres (14 hectares) of riverine barrens consisting of unconsolidated sand and gravels with some early successional stages of gravel bar plant communities. These communities are regularly disturbed by river flooding. North of the proposed mine on higher ground, vegetation consists predominantly of wet tundra with *Carex aquatilis*, moist tundra, and dry prostrate shrub tundra (BPXA, 1997:2-4). This habitat would not be disturbed in the process of gravel mining. The gravel mine site is primarily unvegetated, but any pioneer vegetation, such as annual forbs, herbs, and shrubs, established on the sand and gravel of the site would be removed with the snow and ice to prepare the area for gravel mining.

This terrestrial habitat at the gravel mine site would be converted to aquatic habitat after gravel extraction activities are complete. The mine would be connected by a channel to the Kuparuk River and allowed to flood during the breakup period. This would result in creation of a 30-acre (12.1-hectare) lake with depth of up to 40 ft (12.2 m) and would include at least 4 acres (1.6 hectares) of a 6-ft (1.8 m) deep shelf along the south side of the mine site (Figure 4-16). The shallow areas of the lake likely would not support emergent vegetation such as *Arctophila fulva* or *Carex* sp. due to the water depth. The habitat created by gravel mining would consist of a deep, open water lake which would not freeze to the bottom during the winter, providing fish overwintering and rearing habitat as invertebrates would be available as a food source.

Loss of the river bar habitat would decrease the amount of this habitat in the local area. The river bar habitat is sparsely vegetated and temporary in nature, due to regular flooding and erosion. Impacts on vegetation and invertebrates from the loss of river bar habitat are considered to be minor, due to the abundance of this habitat in the general area.

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Ice road construction over tundra habitat during gravel mining activities and onshore pipeline construction would consist of 2.8 miles (4.5 km) of ice roads from the mine site to the freshwater lake which would supply water for ice road construction, and along the pipeline route from landfall, as applicable to each alternative (BPXA, 1997:2-4). Thirty-one acres (12.5 hectares) of moist tundra and 6 acres (2.4 hectares) of wet tundra would be affected by the ice road to the water supply source. The access ice road at Point McIntyre would impact approximately 3.7 acres (1.5 hectares) of moist tundra. Ice roads remain in place later in the spring compared to snow on the adjacent tundra and green up later due to the ice cover. Ice roads also tend to compress the vegetation for a couple of years after initial construction and result in less microtopographic variation. Recovery of the microrelief is expected to occur over a couple of years through action of the freeze/thaw cycle (Walker et al., 1987:24). Tundra vegetation is expect to recover within a few years; therefore, impacts are expected to be short-term and would be considered minor.

A small portion of the onshore pipeline corridor for Alternatives 2 and 3 was disturbed in 1969 by construction of a "peat road" south from Point Storkersen, which is still visible as a raised area with ditches on either side and is in various stages of erosion and revegetation. The proposed pipeline would follow this road for a short distance south of Point Storkersen and travel east toward the Point McIntyre Facilities. The peat road is not in a usable condition and would not be improved to provide access to the pipeline; however, following this road minimizes additional disturbance to undeveloped tundra areas.

Construction of the onshore pipelines would be conducted during the winter months. Ice roads would be built over the frozen tundra along pipeline routes. Holes for the VSMs to support the pipelines would be drilled through the ice road, and tailings from these holes would be removed and disposed. There would be no permanent access roads built adjacent to the pipelines, thereby minimizing impacts to the tundra and avoiding alteration of drainage patterns and water impoundments that might affect coastal vegetation and invertebrates. Because no fill will be required for the pipeline, the impact would be compression of tundra vegetation from the construction of ice roads. For Alternatives 2, 3, 4, and 5, the ice road along the onshore pipeline would affect a total of 262.7 acres (106.3 hectares), 235 acres (95.1 hectares), 180 acres (72.8 hectares), and 163 acres (66 hectares), respectively (Table 6.6-2). The amount of each tundra type affected by an ice road footprint from Alternatives 2, 3. 4. and 5 is presented in Table 6.6-3.

The pipeline routes avoid all major thaw-lakes and large tundra ponds, and the placement of VSMs in the smaller tundra ponds would depend on final pipeline alignment. Two additional VSMs would be placed in the Putuligayuk River at the crossing to support the new pipeline. These supports would be installed during the

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winter months to minimize effects on riverine habitat. Therefore, impacts to aquatic vegetation and habitats are considered to be minor.

Essentially all of the pipeline route is across wet, aquatic, and moist tundra wetlands, with very minor amounts of dry tundra associated with elevated mounds (USDOI, FWS, 1991:1). Total loss of wetland habitat from placement of VSMs and fill at the valve station would be less than 2 acres (0.8 hectares). This includes the area occupied by each VSM (approximately 96 VSMs per mile [60 per km]) and 0.1 acres (0.04 hectares) of moist tundra for the valve station pad at the Point Storkersen landfall and the excavated trench from the shoreline. Changes in surface hydrology and local drainage patterns would be avoided by the installation of the pipeline on VSMs.

Gravel for the valve station pad would be hauled over an ice road during the winter months, which would limit impacts to adjacent tundra areas. No additional fill would be required for expansion of caribou crossings on the existing pipelines and roads. The size of the area covered by the VSMs and the valve station pad is small relative to the availability of similar, undisturbed tundra habitat in the vicinity and would have a very small incremental effect on the Arctic Coastal Plain. Because ice roads would be used during construction, long-term effects are not expected. Ice roads protect the tundra better than soft-tired vehicles on frozen ground; however, some vegetation would be crushed under the ice and patches of higher ground may be scraped. Studies of vegetation recovery (Emers and Jorgenson, 1997:543; Cargill and Chapin, 1987:386; Strandberg, 1997:16) indicate that recovery of tundra from soft-tired vehicle damage takes place within 7 to 9 years, and associated changes in hydrology result in small areas of subsidence and ponding. A single year of ice road construction is expected to result in much less damage than soft-tired vehicles, and vegetative recovery is anticipated within 2 to 3 years. If ice roads were repeatedly constructed during the life of the project, impacts would be greater. However, impacts would still be less than those of repeated soft-tired vehicle use over the same time period. The hydrology of this area would not be altered by the pipeline and pad, therefore, changes to wetlands are not expected. Placement of the VSMs and pad would be expected to have only a minor impact on coastal vegetation and invertebrates in the project area.

Operation Impacts: Most operational activities would occur on ice roads, at Seal Island, or involve transportation of people and materials between Seal Island and the mainland on ice roads and would have no impact on coastal vegetation and invertebrates. The presence and operation of the pipeline and valve station pad are not expected to adversely affect coastal vegetation or invertebrates; therefore, no impacts are expected.

Oil spills on the tundra or in nearshore water where oil could wash ashore and affect saline tundra constitute the greatest potential adverse effect to wetlands and terrestrial vegetation. Oil can affect tundra by killing all vegetation or portions of the vegetative community, such as the moss and lichens. Plants associated with dry tundra are generally more susceptible to damage from spilled oil in comparison to plants that inhabit wetter tundra communities (Walker et al., 1978:252). Areas of oiled tundra often show a marked increase in thaw depth of the active layer under the contaminated area (Lawson et al., 1978:28; Brown and Grave, 1979:9). Oiled tundra areas are difficult to clean up without further disturbance to the vegetative mat and the permafrost underneath.

Oil spills which reach freshwater lakes and ponds can kill the invertebrate fauna and plankton in the water, contaminate sediments, and kill or injure emergent vegetation. Effects of oil on invertebrate populations can be long-term, depending on the amount of oil contamination of the sediments, since many life stages come in contact with bottom sediments (Bergman, et al., 1977:36). Contaminated sediments would also affect emergent vegetation. Oil in sediments is expected to break down slowly due to the cold temperature (Bergman et al., 1977:36). Impacts of oil to coastal vegetation and invertebrates are discussed in Chapter 8.

Maintenance Impacts: The level of effects on coastal vegetation and invertebrates along the pipeline from maintenance and repair activities would depend on whether it was feasible to defer activities until periods of adequate snow and ice cover. If emergency repairs or unplanned maintenance activities are required during the summer months, only soft-tired vehicles would be used to access the site. Studies of Rolligon use on the tundra have shown that vegetation breakage and displacement of surface soils can occur as a result of soft-tired vehicular traffic (Felix and Raynolds, 1989:189; Walker et al., 1987:22.) Although recovery of the tundra is dependent upon the number of times a site is traversed by such vehicles, studies indicate that recovery of vegetation takes place within 7 to 9 years (Felix and Raynolds, 1989:189; Strandberg, 1997:381; Emers and Jorgenson, 1997:453) after summer use. Use of rolligons on frozen tundra would result in less impacts to the tundra than summer use, because, although impacts may include similar damage to vegetation, little frozen soil would be displaced. Impacts to the tundra under these circumstances, would be considered minor and short-term. Potential impacts are reduced by conducting routine inspections of the pipeline during the winter on snowmachine or by helicopter. Regular inspections and maintenance activities would have no effect on the tundra. The pipeline will be monitored by helicopter.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to coastal vegetation and invertebrates would be expected to be similar to the minor impacts generated during construction.

6.6.3 Summary of Environmental Consequences

Except for oil spills (Chapter 8), no significant adverse impacts were identified for coastal vegetation and invertebrates as a result of development of the proposed project. Tundra vegetation would be impacted from late melting of ice roads, fill of wetlands for the installation of the valve stations, and placement of the VSMs. Oil spills could potentially have significant adverse impacts on freshwater invertebrates, with oil spill reponse activities potentially resulting in significant impacts to coastal vegetation.

Alternative 1 will result in no impact to coastal vegetation or invertebrates. Existing vegetation communities would not be altered by ice road construction or by fill of tundra habitats. River bar habitat at the Kuparuk River delta would not be disturbed.

The development of any of the Alternatives 2, 3, 4, or 5 would result in minor loss of river bar habitat on the Kuparuk River Delta. Less than 2 acres (0.8 hectares) of tundra habitat would be lost from placement of fill for the valve station and pipeline VSMs. Ice road construction would result in some compression and late green up of up to 262.7, 235, 180, and 163 acres (106.3, 95.1, 72.8 and 66 hectares) of tundra the first year after onshore pipeline construction for Alternatives 2, 3, 4, and 5, respectively; the impacts would be considered minor. Impacts from the operation and maintenance of Seal Island and the pipelines would also be considered minor.

Development of the ice roads for construction would result in a short-term impact to vegetation which may last for several years. Long-term impacts to vegetation include destruction of tundra habitat for the construction of valve station at the landfall of the offshore pipeline. The operation and maintenance of pipelines and facilities would have no long-term impacts (beyond 15 years) on vegetation or terrestrial invertebrates.

The development of any of the alternatives would require the long-term loss or commitment of river bar habitat at the gravel mine site and the filling of small areas of tundra for the valve station will be an irreversible commitment of resources. The onshore pipeline would not require fill, and after abandonment, this area could be restored to its former habitat. The removal of the pipeline during project abandonment would allow return of the habitat.

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6.7 BIRDS

Bird species found in and around the project area, and any impacts to those species from the project, are described in this section. Threatened and endangered bird species (spectacled eider *Somateria fischeri* and Steller's eider *Polysticta stelleri*) are discussed in Section 6.9.

6.7.1 Affected Environment

Approximately 44 species of nesting seabirds, waterfowl, shorebirds, raptors, and passerines are found seasonally in the project area (Pitelka, 1974:2; Johnson and Herter, 1989:ix). Additional species are casual or accidental visitors to the project area (Table 6.7-1). Most birds in the region are migratory and present on the Arctic Coastal Plain from late May through September. They take advantage of the short summer to feed, nest, rear their young, molt, and stage for fall migration to wintering areas (Johnson and Herter, 1989:x).

The Alaskan Beaufort Sea coast, which includes the coastline of the project area, is important for a number of marine-oriented birds as a summering area for non-breeders, post-breeding staging, and as a migratory pathway, but lacks the rock cliffs and talus slopes for seabird breeding colonies (Divoky, 1984:417). Coastal areas are used for molting by several waterbird species, and for accumulating energy stores in the fall for southward migration (Johnson and Richardson, 1981:298). Many of these species are international, migrating from as far away as South America, southeast Asia, the Pacific Islands, and Antarctica (Johnson and Herter, 1989:ix). Local residents have observed that large numbers of waterfowl pass through this area, and are

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concerned that an oil spill could have a drastic effect on the population (F. Rexford in USACE, 1996:22). During summer, overall bird densities are generally low but, because they are spread over such a large area, total populations are often large (Johnson et al., 1987:131). Location of major bird concentration areas are shown on Figure 6.7-1.

Although the number, migration corridors, and staging periods of spring and fall migrating seaducks (oldsquaws [*Clangula hyemalis*] and common, king, and spectacled eiders [*Somateria mollissima, S. spectabilis,* and *S. fischeri*]), red-throated and Pacific loons (*Gavia stellata* and *G. pacifica*), and Pacific black brant (*Branta bernicula*) along the Alaskan Beaufort Sea coast have not been reliably estimated (Richardson and Johnson, 1981:117; R. Oates - Pers. Comm., 1998:1), the importance of the nearshore habitats, lagoons, barrier islands, and offshore areas to migrating, staging, and molting waterbirds is well documented (Bergman et al., 1977:7; Schamel, 1978:55; Richardson and Johnson, 1981:117; Johnson and Richardson, 1982:290; Johnson, 1985:21; Johnson and Herter, 1989:83; Suydam et al., 1997:534).

Few birds remain in the project area throughout the year. Resident species, those which spend the entire year in the region, include the common raven (*Corvus corax)*, willow and rock ptarmigan (*Lagopus lagopus, L. mutus*) and, possibly, the hoary redpoll (*Carduelis hornemanni*) and gyrfalcon (*Falco rusticolus*) (Pitelka, 1974:175-176; Johnson and Herter, 1989).

6.7.1.1 Seasonal Movements and Activities

There are three periods of bird migration along the Alaskan Beaufort Sea coast: spring migration, molt migration, and fall migration. Spring migration begins approximately mid-May with migrants arriving from two directions (Johnson and Richardson, 1982:291). Birds coming from wintering areas to the west, such as the Bering and Chukchi Seas, follow either an inland route east across the Arctic Coastal Plain, or the open lead system in the offshore ice (Section 5.6). The leads generally occur within 6 miles (9.7 km) offshore of the barrier islands, but can be found as far as 24 miles (38.6 km) offshore (Flock, 1973:267; Johnson and Richardson, 1981:131). Birds migrating from the eastern and central portions of North America approach the Alaskan Beaufort Sea coast from the east, generally following an interior route through the major river drainages in Canada, then following the coast westward to reach the project area (Richardson and Johnson, 1981:108). A large percentage of spring migrants, especially waterfowl and shorebirds, take this eastern route into the Alaskan Beaufort Sea (Richardson and Johnson, 1981:110).

During spring migration (approximately May 15 to June 20), thousands of spectacled eiders, tens of thousands of common eiders and Pacific black brant, and hundreds of thousands of king eiders and oldsquaws migrate along the Alaskan Beaufort Sea following coastal, nearshore, and/or offshore routes. Observations of Pacific black brant; common, king, and spectacled eiders; and oldsquaw during spring migration have been recorded at Point Storkersen between June 1 and June 10 (Bergman et al., 1977:6).

Much of the tundra is still frozen when migrants arrive and waterbirds concentrate in areas along the coast, flooded habitats at the mouths of rivers, snow-free areas along the roads, and meltwater ponds (Johnson et al., 1987:132). When the ice and snow thaw, they disperse to breeding areas (Richardson and Johnson, 1981:108).

As snow melt progresses, birds establish territories and nest on the newly exposed tundra. A few species utilize isolated offshore islands for nesting, which provides protection from predators. Incubation is initiated in early June and lasts for 3 to 4 weeks, with eggs hatching from late June through mid-July. Most young are generally reared from mid-July to mid-August. Some species are territorial and nest in the same locations from year-to-year, while others are more nomadic and nest where environmental conditions are favorable each year.

Birds are most vulnerable to oil spills during spring and fall migration and the post breeding, molting, and brood-rearing period (generally late June through mid-August). The post-breeding period is characterized by a general movement of shorebirds and waterfowl from nesting areas on the tundra to coastal feeding areas prior to migration (Connors et al., 1979:108; Connors, 1984:407). The movement to the coast makes many species vulnerable to potential oil spills. Waterfowl usually move their broods to rearing sites, which may be in different habitat from nesting areas. Brood-rearing areas are traditional for some species and are important for putting on fat reserves for migration (Johnson, 1991:10-15; Stickney and Ritchie, 1996:50). Other species remain on lakes and ponds within their tundra nesting areas until late fall (Johnson and Richardson, 1981:220). In late July, molting waterfowl in the lagoons are joined by thousands of juvenile phalaropes, as the young fledge (start to fly) and move from tundra breeding grounds to feed on the marine zooplankton concentrated along the beaches of the islands, especially along the outer coast (Johnson and Richardson, 1981:286; Connors 1984:407).

Molt migration is a post-breeding movement of waterfowl to areas not directly on the route to wintering grounds. For most, this occurs during mid-summer; however, it varies by species. Some non-breeding or unsuccessful nesters move from the breeding grounds to communal molting areas at either coastal lagoons or large lakes. Waterfowl cannot fly while molting, and water-bodies provide protection from predators (Johnson and Richardson, 1982:291). Some species move to the coast near their breeding grounds while others fly considerable distances, even hundreds or thousands of miles, to molt at traditional sites. Large numbers of common and king eiders (primarily males) undergo post-breeding molt migrations from northern nesting areas to presumed molting areas in the Chukchi and Bering Seas. Simpson Lagoon is one such traditional molting site (Johnson and Richardson, 1982:294). These flightless ducks, mostly oldsquaws, are vulnerable to both disturbance and to oil spills.

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Fall migration extends over a longer period of time than spring migration, with the non-incubating member of the pair of some species, such as pectoral sandpipers (*Calidris melanotos*), red phalaropes (*Phalaropus fulicaria*), and red-necked phalaropes (*P. lobatus*), leaving the breeding ground soon after the eggs are laid, followed several weeks later by the other parent and fledged young (Connors, 1984:406). In contrast, red-throated loons, Pacific loons, and tundra swans (*Cygnus columbianus*) remain on their breeding grounds until freezing weather forces them to leave (Johnson and Richardson, 1981:192). The majority of the fall migrations occur from mid-August to mid-September and typically involve feeding and staging in coastal areas to build up energy reserves for the long flight to wintering areas (Johnson and Richardson, 1981:286; Connors, 1984:412). Fall migration of seaducks, and most species of waterbirds, occurs from approximately mid-July through early November.

6.7.1.2 Habitats

The central portion of the Arctic Coastal Plain, from the Colville River to the Canning River including the project area, is regarded as having a relatively high diversity of bird habitat due to the large rivers with delta systems, barrier island/lagoon systems, extensive wetlands, and numerous ponds and lakes (Pitelka, 1974:173). A total of four different habitat types are important to birds in the project area and could potentially be impacted by the project: offshore marine waters, nearshore marine waters, barrier islands, and tundra habitats.

Offshore Marine Waters: Offshore waters are those outside the barrier islands from 10 to 165 ft (3 to 50 m) deep. Summer bird densities in offshore waters are the lowest of any marine area adjacent to Alaska. This is probably a reflection of the low primary productivity of the Alaskan Beaufort Sea (Divoky, 1984:431). There is a general absence of diving birds in the offshore waters, with the exception of small numbers of thick-billed murres (*Uria Lomuia*) and black guillemots (*Cepphus grylle*) (Divoky, 1984:424). Only a few surface-feeding bird species utilize the offshore waters, such as the red and red-necked phalaropes, pomarine and parasitic jaegers (*Stercorarius pomarinus and S. parasiticus*), Arctic tern (*Sterna paradisaea*) and, the dominant species, glaucous gulls (*Larus hyperboreus*) (Divoky, 1984:424). Density of birds during the open water season in deeper offshore waters greater than 60 ft (18 m) is relatively low at less than 25.9 birds per square mile (10/km^2); however, density increases in shallower nearshore waters to greater than 259 birds per square mile (100/km^2) (Divoky, 1979:359).

Nearshore Marine Waters: Nearshore marine waters, defined as less than 10 ft (3 m) deep, support many more birds than offshore waters. The shallow, brackish lagoon systems enclosed by barrier islands, such as Simpson Lagoon and Gwydyr Bay, are major components of the nearshore environment. These lagoons provide feeding habitat, as well as resting habitat and escape cover for large numbers of molting waterfowl. Other important habitats associated with nearshore marine waters are saline tundra (salt marsh) areas, which occur along protected coastlines adjacent to lagoon systems or at extensive river delta systems. These saline tundra areas are of major importance to Pacific black brant.

Diving birds which use the nearshore waters for feeding include red-throated loons (*Gavia stellata*) and Pacific loons, waterfowl, such as oldsquaw; and common, king, and spectacled eiders. Oldsquaws are the most numerous species with tens of thousands congregating in the lagoons from mid- to late summer, often in the lee of points, islands, and causeways during winds (Johnson and Richardson, 1981:114). Other species found abundantly in nearshore waters are glaucous gulls (Divoky, 1984:427) and red and red-necked phalaropes, typically on the seaward side of the barrier islands (Johnson and Richardson, 1981:116).

Barrier Islands: Most islands in the project area are composed of gravel and sand with patchy vegetative cover (Section 6.6.1.3) and provide a moderate amount of nesting habitat for occasional brant, low numbers of common eiders, glaucous gulls, and Arctic terns (Schamel, 1978:57; Johnson and Richardson, 1981:224). Some of the larger barrier islands support small numbers of tundra nesting shorebirds, such as ruddy turnstones *(Arenaria interpres)*, dunlins *(Calidris alpina)*, and Baird's sandpiper *(C. Bairdii)*, but overall densities are not as high as adjacent mainland tundra habitats (Johnson and Richardson, 1981:224). Common eiders nest almost exclusively on barrier islands and select nest sites among the drift debris and *Elymus* clumps. The only passerine (songbird) species that regularly occurs on these islands is the Lapland longspur (*Calcarius lapponicus*).

Tundra Habitats: Tundra habitats adjacent to the Alaskan Beaufort Sea coast are breeding habitats for most birds using nearshore marine areas. Most of the habitat available to birds consists of moist and wet tundra, aquatic tundra, large lakes and ponds with islands (Section 6.6.1). This is reflected in the high percentage (80%) of water-oriented birds dominating the avifauna (Bergman et al., 1977:8). The wet and moist tundra habitats produce a variety of different microsites for different activities, such as feeding and nesting, with the latter occurring on drier microsites (Troy, 1988:71 and 74). The dominant shorebird species such as semipalmated sandpiper (*Calidris pusilla*), dunlin, and pectoral sandpiper, prefer wet tundra habitats (Bergman et al., 1977:25; Troy, 1988:74-77).

Tundra habitats within the onshore project area and adjacent to Prudhoe Bay are intensively studied Arctic bird habitats. Numerous short-term studies dealing with the effects of oil development on various aspects of bird biology have used reference or control plots located in a large block of undeveloped tundra west of Prudhoe Bay and south of Point McIntyre, referred to as the Point McIntyre Reference Area. This area is used to represent relatively undisturbed habitat (TERA, 1993b:2). Regular census of this area from 1981 to 1992 has led to the accumulation of over a decade of breeding season data from the same area, providing a good time series of annual variation for both habitat use and long-term regional population trends on the central Arctic Coastal Plain (TERA, 1993b:3). The habitat and species composition of this reference area is generally similar to many areas on the Arctic Coastal Plain, although some habitats and species that occur throughout the Arctic Coastal Plain are poorly represented in the Point McIntyre Reference Area (Troy, 1995:16; TERA 1996:23-24).

Waterfowl species that nest in tundra habitats in relatively low densities include tundra swans, greater white-fronted goose (*Anser albifrons*), northern pintail (*Anas acuta*), king eider, and oldsquaw (Warnock and Troy, 1992:13). The only common tundra-nesting passerine is the Lapland longspur (TERA, 1990b:13).

Non-breeding birds and transients make up a considerable portion of birds present on the tundra during the breeding season, with numbers of non-breeding birds fluctuating considerably more than the number of breeders (TERA, 1990b:16). Environmental factors or recruitment from previous years' production are the likely cause for fluctuation of bird numbers on the tundra during the breeding season (TERA, 1993b:24).

The density of dominant nesting species in tundra habitats of the Point McIntyre Reference Area has been relatively stable over 11 years of documented study (1981 to 1992). Some species have shown a declining trend in breeding-season density during these years, including the Lapland longspur, pectoral sandpiper, dunlin, king eider, and oldsquaw (TERA, 1993b:22). However, causes for these declines have not been linked to oil field development. The pectoral sandpiper and Lapland longspur have exhibited noticeable among-year variation over several years of study (TERA, 1993b:26). Pectoral sandpiper fluctuation is likely due to their non-territorial nesting behavior; their breeding locations change from year to year depending on environmental conditions. Causes of Lapland longspur density fluctuations are unknown (TERA, 1992:15).

For dunlin, density of birds seen during the breeding season at the Point McIntyre Reference Area declines during 1981 and 1992 (TERA, 1993b:Table 10) and king eider and oldsquaw declines during 1981 to 1992 approached statistical importance (TERA, 1993b:17). Although dunlin has shown an apparent declining trend during this time period, the decline is not statistically important (TERA, 1993b:17). Although the downward trend in dunlin numbers is evident, the interpretation and importance of this trend is uncertain as the nesting densities did not show a parallel decrease. King eiders migrating past Point Barrow in spring indicate that the population in northern Alaska and western Canada declined by more than 50% between 1976 and 1994 (Conant et al., 1997:17). From 1986 to 1997, oldsquaw breeding populations on the Arctic Coastal Plain remained relatively stable (127,000 to 113,000, $P>0.10$); however, populations in northwestern Canada and southern parts of Alaska declined by 75% (Conant et al., 1997:25). Declines in populations of spectacled and Steller's eiders are discussed in Section 6.9.

6.7.1.3 Loons and Waterfowl

Two species of loons, the Pacific and red-throated, are regular breeders in the lakes and ponds of the onshore portion of the project area. The yellow-billed loon *(Gavia adamsii)* is an occasional breeder. Loons are some of the last birds to arrive in the spring (Bergman et al., 1977:6) and remain until freezing weather forces them to leave (Johnson and Richardson, 1981:192). Red-throated loons prefer to nest along water bodies in basin complexes, but fly to coastal waters to forage on small fish in the nearshore Alaskan Beaufort Sea (Bergman et al. 1977:26-35). Pacific loons generally are found nesting near the larger lakes or ponds containing *Arctophila fulva* (Bergman et al., 1977:26) but also use water impounded beside gravel roads and pads in the oil fields (Kertell, 1993:1). Pacific loons also feed in nearshore marine waters (Bergman et al., 1977:35).

The tundra swan is one of the earliest arriving migrants to the project area (Bergman et al., 1977:6) and is also one of the last species to leave, generally in late September or early October (Stickney et al., 1993:1). These swans return to traditional nesting and brood-rearing areas and, therefore, are more likely to be affected by human development than species which are less faithful to specific areas (Ritchie et al., 1991:1). Tundra swans nest in relatively low densities of 0.01 nests per square mile (0.03 nests per km^2)

and are distributed uniformly at scattered locations on large ponds and lakes throughout the onshore project area (Ritchie et al., 1991:25; Stickney et al., 1993:i).

Several lesser snow goose *(Chen caerulescens)* colonies nest consistently at Howe Island, located in the outer part of Sagavanirktok River delta east of Prudhoe Bay. This is the only snow goose population nesting in proximity to a developed oil field (Johnson, 1994:1).

The greater white-fronted goose is a regular breeder in the project area (Bergman et al., 1977:6; Moitoret et al., 1996:19). Nesting density of these geese increases with distance from the coast (TERA, 1994:13). In the onshore project area, nesting densities near the coast were 0.2 to 0.3 nests per square mile (0.6 to 0.8 nests/km^2), in comparison to 0.6 nests per square mile (1.6 nests/km^2) 12 miles (19.3 km) inland (Troy, 1988:54). The same gradient was seen in the Kuparuk area (Moitoret et al., 1996:19-20). Non-breeders and juvenile birds move to traditional molting and staging areas in larger lakes or coastal areas during the post-breeding period A few weeks later, adults with broods leave tundra brood-rearing areas to join the non-breeders in feeding in saline tundra areas (TERA, 1994:18).

Most of the Pacific black brant (brant) nesting in northern Alaska occur between the Sagavanirktok and Colville River deltas (Stickney and Ritchie, 1996:50). Brant in the project area have been studied since 1984, including systematic aerial surveys between 1988-1992 to document population levels and assess impacts from oil development (Stickney and Ritchie, 1996:48). Most of these birds nest in small dispersed colonies, with a few larger colonies consisting of over 200 nests (Figure 6.7-1). Main nesting areas are located on remnant river delta islands in the project area, including Howe and Duck Islands in the Sagavanirktok River delta and on a small island in the Kuparuk River delta (Stickney and Ritchie, 1996:47). Brant move to coastal brood-rearing areas shortly after the young have hatched (Stickney and Ritchie, 1996:48). Coastal saline tundra habitat, located in relatively small areas of the coast, is important brood-rearing habitat (Bergman et al., 1977:28; TERA, 1994:28; Stickney and Ritchie, 1996:48). Important brood-rearing areas include the Kuparuk and Sagavanirktok River deltas, Point McIntyre, the northwest side of Prudhoe Bay, and near the mouth of the Putuligayuk River at the head of Prudhoe Bay (Stickney and Ritchie, 1996:49). Data from 1988 through 1996 surveys of brant in the Kuparuk River Delta (Stickney et al., 1993:28-29 and 40-41; Anderson et al., 1996:30 and 33) indicate that colony and brood-rearing populations differ greatly from year-to-year. Numbers of nests range from approximately 25 in 1995 to 134 in 1993 (Stickney et al., 1993:34). Similar variability was noted for numbers of brood-rearing groups. Gosling numbers represent approximately 40% to 50% of the total bird count within the region that includes the Kuparuk River Delta. Brant are sensitive to disturbance from aircraft overflights; and noise impacts (Derksen et al., 1992:ii) to this species are further discussed in Chapter 9.

The Canada goose (*Branta canadensis*) is a regular breeder in the project area (Murphy et al., 1987:73 to 78; TERA, 1990b:28). Canada geese stage for fall migration in salt marsh habitats, particularly at the head of Prudhoe Bay (Murphy et al., 1987:94).

Oldsquaw is one of the most common breeding waterfowl species on the tundra in the Prudhoe Bay area (TERA, 1990b:17). Between 250,000 and 1 million oldsquaws migrate into the Alaskan Beaufort Sea region via nearshore and offshore corridors (Bright, 1998:4; Richardson and Johnson 1981:108). During spring, most oldquaws migrate east across offshore portions of the Alaskan Beaufort Sea, rather than along the coast or through the interior (Richardson and Johnson, 1981:118). Because open water is scarce in much of the Alaskan Beaufort Sea in the spring, migrating oldsquaws can be expected to land on any available water in nearshore areas (Schamel 1978:53; Bergman et al.,1977:7; Richardson and Johnson, 1981:118) and in offshore leads. Thousands of migrating oldsquaws have been observed in offshore leads in the Canadian Beaufort Sea during late May and early June (Johnson and Richardson, 1982:298). During July, there is a substantial westward movement of oldsquaws over offshore waters (Johnson and Richardson, 1982:296). Males and non-breeding females undergo molt migration in July and spend several weeks in protected lagoons along the Alaskan Beaufort Sea coast, such as Simpson Lagoon.

Common eiders breeding on the Arctic Coastal Plain are found primarily on the barrier islands (Schamel, 1978:55; Johnson and Herter, 1989:76). Numbers of common eiders nesting in northern Alaska and the western Canadian Arctic may have declined in the last 20 years (Suydam et al., 1997:26). Common eiders were identified as a species at risk by the USFWS (Bright, 1998:4). In 1995, the total numbers of common eiders nesting on Stump, Egg, and Long Islands was 80, 60, and 24, respectively (Troy, 1996:1).

Spectacled eiders are listed federally as threatened under the ESA (58 FR 27480). The Steller's eider was listed federally as threatened under the ESA in June of 1997. These eiders are discussed further in Section 6.9 (Threatened and Endangered Species).

6.7.1.4 Seabirds

The number of seabird species using the Alaskan Beaufort Sea in the summer months is relatively low, likely a reflection of the low biological productivity of the marine waters (Connors, 1984:418). Seabird densities tend to increase to the west of the project area, since biological productivity increases with intrusions of Chukchi Sea water into the Alaskan Beaufort Sea (Connors, 1984:424). Most seabirds which feed in the offshore waters (e.g., jaegers, glaucous gulls, and Arctic terns) also nest in tundra habitats or on barrier islands adjacent to the coast.

6.7.1.5 Shorebirds

Based on breeding season density, shorebirds are the most abundant of the migratory bird species in moist and wet tundra habitats. The six dominant species include: semipalmated sandpiper, pectoral sandpiper, red-necked and red phalaropes, lesser golden-plover (*Pluvialis dominica*), and dunlin (Troy 1988:55, TERA 1992:13). Nest densities and breeding densities for birds common to the Point McIntyre Reference Area are presented in Table 6.7-2. Several species of shorebirds, such as semipalmated sandpiper, dunlin, and pectoral sandpiper, utilize saline tundra and mudflats during the post-breeding period, prior to migrating to wintering areas (Troy, 1995:26). Approximately 24 species of shorebirds have been documented to breed regularly in tundra habitats in the project area (Bergman et al., 1977; TERA, 1990b:13).

Semipalmated sandpipers are one of the most abundant breeding shorebirds in the Alaskan Beaufort Sea and one of the dominant breeders in the project area (Johnson and Herter, 1989:161). These shorebirds use a wide range of tundra habitats, but show preference for wet tundra areas with ridges that provide dry sites for nesting and wet habitats for feeding (Troy, 1988:77-79). Semipalmated sandpipers are monogamous, territorial, and display a strong fidelity to nesting territories and nest sites from year-to-year (Moitoret et al., 1996:34). Nest density of these shorebirds tends to decrease with an increase in oil field development, which suggests they are affected by disturbance (TERA, 1993a:43).

Pectoral sandpipers are one of the dominant nesting species and occur throughout the project area. These shorebirds show a strong preference for wetter tundra communities (Troy, 1988:77-79). They do not maintain breeding territories or return to previously used sites. Therefore, at any one site nesters may be common one year and nearly absent the next (Pitelka et al., 1974:190).

Dunlins are one of the more common species of shorebird in the tundra habitats of the project area, but are less abundant than semipalmated sandpipers. These shorebirds prefer wet tundra habitats and their breeding strategies are similar to those of the semipalmated sandpiper, being monogamous and territorial with a high site fidelity (Troy, 1988:30). Dunlins appear to be one of the more sensitive shorebird species and show a decrease in both nesting and post-breeding density with an increase in disturbance from oil field facilities (TERA, 1990a:43). Dunlins have been identified in one study as one of the species most affected by oil field development (Meehan, 1986:75).

Red and red-necked phalaropes are common “nomadic” breeders in Alaskan Beaufort Sea coastal areas and nest in wet tundra habitats throughout the project area (Troy, 1988:14). These swimming shorebirds do not maintain nesting territories but make use of available habitats. These birds do not show avoidance of roads and facilities, which is contrary to most of the shorebird species inhabiting the Prudhoe Bay area. Phalarope densities often increase adjacent to roads and pads, possibly due to an increase in impoundments along these features which provide the ponds and aquatic tundra they use for nesting and feeding (Troy, 1988:43; TERA, 1993a:43).

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6.7.1.6 Passerines

The Lapland longspur is one of the most widespread and the most abundant tundra-nester in the Prudhoe Bay area (Troy, 1988:51-54). Lapland longspurs show a slight decrease in abundance with increased oil field facilities, such as adjacent to roads and pads (TERA, 1993a:46). The snow bunting (*Plectrophenax nivalis*) nests in cavities and selects sites that are inaccessible to foxes, such as debris piles or pipeline supports, as nesting structures (TERA, 1990a:33). Nesting abundance usually increases around human development, which provides suitable nesting sites. These birds typically are not found in tundra habitat due to the lack of nest sites (Johnson and Herter, 1989:265).

6.7.2 Environmental Consequences

The following sections describe the potential impacts of each project alternative on birds. The discussion of impacts is organized based on project alternatives as described in Chapter 4. The types of construction impacts for Alternatives 2, 3, 4, and 5 are similar, only the amount of habitat affected due to landfall location is different. Impacts from operation, maintenance, and abandonment of Alternatives 2, 3, 4, and 5 are also similar; therefore, impacts for Alternatives 2, 3, 4, and 5 are discussed together and summarized in Table 6.7-3.

6.7.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative, consequently, there would be no impacts to birds. The natural variability in population levels and habitat of birds in the project area and in the Alaskan Beaufort Sea would be undisturbed by a No Action Alternative.

6.7.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Approximately 35 acres (14.2 hectares) of sparsely-vegetated gravel bar would be removed and converted to deep and shallow open water habitat for Alternatives 2, 3, 4, and 5. Gravel bar areas receive only light use by birds during summer months due to a lack of food sources and vegetative cover for nesting. A few birds, such as semi-palmated plover and Baird's sandpiper, prefer open, rocky sites such as river bars for nesting. Therefore, loss of 35 acres (14.2 hectares) of gravel bar habitat is considered a minor impact to birds.

Restoration of the mine site would provide 30 acres (12 hectares) of up to 40-ft (12.2 m) deep open water, and 4 acres (1.6 hectares) of 6-ft (1.8 m) deep open water which is not expected to develop emergent vegetation. The site would be connected to the Kuparuk River, and

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Table 6.7-3 (page 2 of 3)

Table 6.7-3 (page 3 of 3)

occasional flooding and water exchange would occur. Fish may become established in the flooded mine site. A few waterfowl may use the site for resting, and fish-eating loons may feed there. The site is not intended to become high-quality bird habitat. Restoration of the mine site would provide a negligible beneficial impact to birds. Moreover, a few or no birds would be present during the actual mining activities; hence, activities related to gravel mining (e.g., loading trucks) would have negligible impact.

Offshore ice road and winter island construction activities would affect birds only if open water remains around the island into early spring when eiders and oldsquaw return to the area. Attraction to this open water is not expected to adversely impact the birds. Since few birds would be present during winter, construction of ice roads and the island would have a negligible impact on birds. During the open water period, the lee side of the island may become an attractive loafing area for oldsquaw, eiders, guillemots, and gulls; however, relatively few birds are expected to use the area due to the distance offshore and those that do, can move away from noise and disturbances. Therefore, the impact from these construction activities is considered negligible.

Approximately 2 acres (0.8 hectares) of tundra will be lost due to placement of gravel for the valve station pad near the shoreline and placement of VSMs for pipeline supports. The largest site, the valve station pad at Point Storkersen adjacent to the coast, is in moist, frost-boil tundra. Based on studies of bird impacts from previous gravel/pad construction elsewhere in the project area, the few birds that may nest in this area are expected to be displaced to nearby habitats with no loss of productivity (TERA, 1990a:33). Impact from the small amount of habitat loss to birds would be considered a minor impact.

Indirect impacts from onshore pipeline construction include temporary disturbance to vegetation under the ice roads used for winter pipeline construction. Using the maximum ice road width of 130 ft (39.6 m), this area is estimated at approximately 16.5 acres/mile (4.15 hectares/km), which includes tundra, small ponds, and unvegetated areas. Tundra vegetation under ice roads is likely to become snow- and ice-free later in the summer following its construction than would otherwise be the case and also would become slightly flattened (Walker et al., 1987:24). Therefore, this habitat would not be available until after the start of nesting. In some areas, drifting snow may accumulate next to the pipeline each winter, resulting in an annual pattern of delayed snow melt. A 5-ft (1.5 m) high pipeline, however is unlikely to cause this effect except in small areas directly adjacent to the VSMs.

During the first year of construction for Alternatives 2, 3, 4, and 5, the delay in nest site availability due to late melting of ice roads along the pipeline would affect a total area of 262.7 acres (106.3 hectares), 235 acres (95.1 hectares), 180 acres (72.8 hectares), and 163 acres (66 hectares), respectively (Table 6.6-2). Any territorial shorebirds, Lapland longspurs, and oldsquaws which nest along this area could suffer nest site loss as a result of onshore pipeline construction. Species which do not nest in the same areas each year (non-territorial), such as the pectoral sandpiper and phalaropes, would establish nests elsewhere and would not be greatly affected. Flattening of vegetation may discourage use of traditional nest sites in the ice road corridor for several years after the initial year of slow melting (Walker et al., 1987:25). Effects would be the same as in the first year, and these would continue until the vegetation recovers to its full coverage and shape. Birds would likely use the areas covered by the ice road for foraging later in the summer after the ice melts. Considering that this loss of habitat for nesting would be relatively small and that territorial displaced birds will likely move to adjacent habitat to nest (TERA, 1990a:33), impacts to these birds are expected to be minor. For non-territorial birds, impacts of habitat loss from ice roads would be expected to be negligible since they would typically not return to the same site each year. Effects of ice road and pipeline construction along existing roads and pipelines are expected to be less than the effects on undisturbed tundra because no new types of activities would be added. Bird species sensitive to construction and road activities have likely already abandoned the existing road and pipe corridors.

Some shorebird species, such as Baird's sandpiper, prefer an exposed nest site with recently disturbed ground nearby (TERA, 1990a:25). These species may move in to use the disturbed area adjacent to the new pipeline. Snow buntings also benefit from a new pipeline as it increases nest site opportunities with each open cavity added. Numerous snow bunting nesting opportunities are expected on new pipeline supports, producing a beneficial impact for this species.

Very few birds, possibly common ravens or ptarmigan, would be present in the project area during winter. No birds would be expected in the offshore area. As a result, both the onshore and offshore pipeline construction would be expected to have negligible impact on birds.

Summer-time construction activities would be limited to installation of building foundations on Seal Island, grading island slopes, installation of geofabric and island slope protection, sealift arrival, and module installation. These activities are similar to the effects associated with maintenance activities described later in this section. Most activities will have a negligible to minor impact to birds; however, impacts to oldsquaws and common eiders from aircraft overflights in nearshore waters would be significant.

The major source of noise affecting waterfowl during open water construction activities are helicopters flying to the island. Helicopter flight path and altitude is an important factor for waterfowl during the summer post-breeding season and staging for fall migration. Information provided by BPXA and ERA Aviation, Deadhorse (Glover - Pers. Comm., 1998:1) indicates that helicopter support for Northstar primarily will be provided from the Deadhorse Airport; however, the Prudhoe Bay airstrip (operated by ARCO Alaska, Inc.) also will be used, if necessary. Helicopter flights between the Kuparuk airstrip and Seal Island are not planned (Glover - Pers. Comm., 1998:1), occasional trips may take place. Overflight restrictions currently are in place for Howe Island to avoid harassment of nesting snow geese. Pilots are requested to avoid harassment of wildlife elsewhere by either altering flight paths or maintaining sufficient altitude. Round trip flights to Seal Island (Chapter 4) are expected to total 1,100 during island construction, range from 1,140 to 1,380 during module installation (depending upon single-season and two-season construction), and total about 30 during drilling. The majority of flights during island construction would take place during April through August; flights associated with module installation would take place from late-August through November; and flights associated with drilling activities would take place throughout the year. Flights during the summer to early-fall would coincide with nesting, brood-rearing, and molting periods and could disturb birds.

Oldsquaw, common eiders, and surf scoters are also affected by low-level overflights (Gollop et al., 1974:202). Molting seaducks in lagoons tend to seek out sheltered areas during inclement weather, and if they are displaced from these areas, stress levels would increase (Gollop et al., 1974:202-232). Birds may move away from better feeding sites or protected areas because of the disturbance. Repeated low-level flights over molting aggregations of oldsquaws could displace those oldsquaws within the flight corridor. Foraging birds on the water or on land, and seabirds between the barrier islands and Seal Island, are more widespread and likely to suffer only temporary adverse impacts to individuals. Peak densities of molting oldsquaws in nearshore lagoons may reach 1,465 birds/square mile (566 birds/km2), a total of approximately 50,000 birds (Johnson and Herter, 1989:100). It can be assumed that up to 22,000 oldsquaw could be present in the eastern boundary of Simpson Lagoon and Gwydyr Bay based on the maximum density of 1,466 birds/square mile (566 birds/km2)(Johnson and Herter, 1989:100), and could potentially be affected by aircraft overflights of this area. If impacts to the species were to occur during the molting period, which extends from mid-July through mid-September, energy demands could increase and affect the growth of new flight feathers. Furthermore, populations of oldsquaw in Canada and parts of Alaska are declining (Conant et al., 1997:n.p.). Since large portions of these oldsquaw populations migrate through coastal lagoons in the project area, disruption from helicopter traffic through Simpson Lagoon could contribute to their overall declining numbers. Overall impacts to oldsquaws and common eiders from aircraft overflights would be significant during construction, and minor during operation. Impacts to most other seabirds and sea ducks would be negligible.

Operation Impacts: Operation impacts for Alternatives 2, 3, 4, and 5 are the same. Under routine operations, birds would primarily be affected by increased levels of noise, activities, and helicopters and vessel traffic to the island. Birds, primarily glaucous gulls and ravens, would also be attracted to potential food sources. Winter transportation over an ice road or by helicopter is not expected to affect birds, as few remain in the area during winter. During the open water season, activities would include small boat and barge traffic between West Dock and Seal Island, arrival of sealift barges from the west, and helicopter traffic between the Deadhorse Airport, Prudhoe Bay airstrip, or Kuparuk airstrip and Seal Island. Flight paths are assumed to be direct from the airports to Seal Island.

Small boat and barge activity between West Dock and Seal Island would disturb resting, feeding, and molting waterbirds using that area. A large number of birds that congregate in the lee of the West Dock causeway could be disturbed with each trip. Molting waterfowl, such as swans, brant, and large groups of oldsquaws in Simpson Lagoon/Gwydyr Bay and near the causeway would be vulnerable to disturbance from boat traffic. A single or occasional disturbance would constitute a negligible impact, but repeated flushing from protected resting areas could result in the expenditure of greater amounts of energy which would normally be used for feather molt and migration. Birds could be forced to move to adjacent areas with less disturbance, which would constitute a minor impact. Offshore of West Dock and the barrier islands, birds are more widely scattered and disturbance would be short-term and affect few birds. Sealift barges and more frequent, smaller, faster boat traffic from West Dock could have a minor impact on molting/staging waterfowl. Glaucous gulls, which roost on barges, may be attracted to a potential food source while barges are being unloaded. Overall impacts to birds, in offshore waters, from small boat and barge activity would be minor.

Helicopter traffic is expected to be frequent during some stages of the project, such as during freezeup and breakup when it is the only means of transportation. Low clouds and fog, which occur frequently in the area during breakup and summer, result in helicopters flying at elevations less than 200 to 500 ft (61 to 152.4 m). Pipeline inspections also would be flown at low elevations. Impacts to nesting birds would depend on the altitude, flight path, and frequency of flights, as well as the species. Reactions would range from birds sitting tight on the nest to flushing and exposing eggs or young to chilling or predation. Birds molting or caring for broods are most likely to react negatively to aircraft because of their vulnerability. Although the populations of oldsquaw on the Arctic Coastal Plain have remained relatively stable (127,000 to 113,000 from 1986 to 1997), breeding population data from parts of Alaska south of the Brooks Range and parts of northwestern Canada show a 75% decline (Conant et al., 1997:17). Since large portions of these three populations migrate through the project area (Johnson and Herter, 1989:97), it is possible that disruptions which occurred in areas such as Simpson Lagoon, and which resulted in a lower survival rate, could contribute to their overall declining numbers. Birds would be most impacted at molting areas in Simpson Lagoon and at brood-rearing areas in the flight path.

Brant are the most likely species to be affected by low-elevation aircraft traffic. Brant would be adversely affected if loss of productivity from disturbance as a result of helicopter overflights (200 - 500 feet [61.0 - 152.4 m]) affected local populations. Impacts could include disruption of nesting, reduced feeding time, and jeopardizing the intake and storage of energy needed for fall migration. The flight corridor between Deadhorse and Seal Island will fly over approximately 11 to 30 brant nests (Stickney and Ritchie, 1996:47). This flight path passes within 5 miles (8 km) of the Kuparuk River Delta colonies. The flight corridor between the Kuparuk airstrip and Seal Island will overfly approximately the same number of brant nests, and this corridor passes within 2.5 miles (4 km) of the Kuparuk River Delta colonies. Such overflights have been shown to negatively affect brant (Derksen et al., 1992:ii). Although helicopter flights between the Kuparuk airstrip and Seal Island are not planned (Glover – Pers. Comm., 1998:1), occasional trips may take place. Impacts to brant from helicopter overflights would be minor. Information about impacts to brant from aircraft noise is provided in Chapter 9.

Oldsquaw, common eiders, and surf scoters (*Metanitta perspicillata*) are also affected by low-level overflights (Gollop et al., 1974:202). Molting seaducks in lagoons tend to seek out sheltered areas during inclement weather, and if they are displaced from these areas, stress levels would increase (Gollop et al., 1974:202-232). Birds may move away from the better feeding sites or protected areas because of the disturbance. Repeated low-level flights over molting aggregations could result in an impact to local populations. Foraging birds on the water or on land, and seabirds between the barrier islands and Seal Island, are more widespread and likely to suffer only temporary adverse impacts to individuals. Overall impacts to oldsquaws, common eiders, and surf scoters from aircraft overflights would be minor. Impacts to most other seabirds and seaducks would be negligible.

Eight of the ten common tundra-nesting shorebirds have displayed some degree of avoidance of oil field facilities, such as roads and facilities (TERA, 1993a:43-44). These include the lesser golden-plover, semipalmated sandpiper, pectoral sandpiper, dunlin, stilt sandpiper, buff-breasted sandpiper, red-necked phalarope, and red phalarope (TERA, 1993:41). There would be a small displacement of nesting shorebird species overall. This would have a minor impact on birds and their productivity but would have a negligible effect on the shorebird populations in the area adjacent to the pipeline. This is due to the relatively small area affected by the placement of gravel for the valve pads and installation of VSMs.

Other potential hazards which could affect birds include the gas flare and presence of aboveground structures and lights at Seal Island. The gas flare could attract birds during migration or periods of low visibility and result in birds getting too close and being killed. Overall impact to birds from the flare and lights, at Seal Island would be expected to be minor.

Aboveground structures at Seal Island would constitute a potential collision hazard to migrating birds because the island is located within a major offshore migration corridor of sea ducks (oldsquaws and common, king, and spectacled eiders); Pacific, red-throated, and yellow-billed loons; Pacific black brant; and shorebirds (red and red-necked phalaropes). Migration corridors vary among species and season. Numbers of waterbirds during migration involves thousands of spectacled eiders, tens of thousands of common eiders and black brant, and hundreds of thousands of king eiders and oldsquaws. Flight altitudes of migrating waterbirds are often low. For example, 46% of oldsquaws fly at less than 6.6 ft (2 m) above the water or ice surface. Half of all surf scoters and 88% of eiders migrating along the coast fly at less than 32.8 ft (10 m) above the water or ice (Johnson and Richardson, 1982:Figure 3). Inclement weather, particularly fog and snow, would likely increase the potential and magnitude of strikes.

There is the potential for migrating birds to be injured or die as a result of collision with production facilities at Seal Island. Although collision is considered a minor impact to migratory birds, the USFWS will recommend appropriate measures to avoid or minimize effects.

The attraction and availability of an artificial food resource and a new breeding area could result in an increased number of gulls and ravens near Seal Island. Increased productivity of gulls and ravens could decrease the productivity of other bird species on nearby barrier islands and the mainland. Predation by gulls on common eiders has been shown to substantially decrease eider productivity in other areas (Mendenhall and Milne, 1985:155; Barry and Barry, 1990:47; Bowman et al., 1997:26). This can be minimized by containing garbage. The impact to birds would be minor and would be expected to be negligible if no additional food source or nesting area is provided.

Sea ducks and phalaropes may congregate in the lee of the island to some extent during the summer to feed in the shallows or along the shoreline. This may result in a slightly beneficial effect for a small number of birds. However, in early winter, ice may form later in the lee of the island and these birds could linger in the open water and potentially be trapped by the ice. This would potentially impact only a relatively low number birds and would be considered a minor impact to individual birds and would not be expected to impact local populations.

Oil spills present the greatest potential impact to birds from development of the project. Birds are particularly susceptible to oil because it coats their feathers, destroying the insulating properties of the feathers, and the birds may succumb to hypothermia (Hansen, 1981:1). Birds can also be affected by the toxicity of oil ingested from preening of oiled feathers or from ingestion of oil-contaminated food (Hansen, 1981:1; Nero, 1987:III). Birds that could be impacted by an oil spill are those found in the project area, although birds outside the project area could be affected if spills persist over long time periods (over 30 days). Long-term spreading of spilled oil could affect birds at a considerable distance from the spill site, such as the black guillemot colony located on Cooper Island, approximately 100 miles (164 km) to the west. Survival of oiled birds is typically poor, and considering the environmental conditions and remoteness of the Alaskan Beaufort Sea area which limits human intervention, it is likely that most birds coming into contact with oil would perish (Hansen, 1981:1). Most birds that die at sea are not washed ashore, so the effects of a spill are often uncertain or unknown.

Indirect effects of an oil spill include displacing birds from important feeding habitat, such as saline tundra, due to contamination of the areas, which could affect both vegetation and invertebrate prey species. This displacement could in turn, affect buildup of energy reserves needed for molt or fall migration and cause the mortality rate to increase.

Terrestrial birds are not as susceptible to oil, but there is some potential for contacting oil spilled on the ground from pipeline leaks during the summer months. Contact with oil can also result in contamination of eggs or young. Likelihood of injury from a spill is much less in comparison to marine and aquatic bird species. Impacts to birds from an oil spill in the project area are discussed in Chapter 8.

Maintenance Impacts: Impacts to birds from maintenance activities along the offshore pipeline and at Seal Island are the same for Alternatives 2, 3, 4, and 5. Seabirds and waterfowl that gather in the lee of the island would be affected by work on the island slopes outside the sheet pile wall. Repair work on the concrete mat on the island slopes or on the submerged gravel berm is not expected to affect birds roosting, foraging, or resting near the island. Therefore, impacts are expected to be negligible.

Normal planned maintenance activities would have no effect on birds near the onshore pipeline since they could be scheduled around critical time periods for birds (November through April). These activities would include visual inspection of the pipe and VSMs, and periodic maintenance of pipeline associated equipment. These activities would be conducted on four wheelers or snowmachines depending upon the time of the year. The pipeline will be monitored by aerial reconnaissance. Unplanned maintenance activities during the nesting season that require activity along the pipeline are likely to cause nesting birds to flush from their nests if humans come close to the nest site. Birds with broods of young are expected to return to normal activities after disturbance. If onshore pipeline inspection results in the need for summertime repair work, impacts to birds would occur over a longer period.

For each of the action alternatives, low-elevation helicopter overflights will be flown along those portions of the routes traversing roadless tundra. Alternative 2 and portions of Alternative 3 represent the longest lengths of pipeline through undeveloped areas (9.5 and 6.7 miles [15.2 and 10.8 km], respectively). Weekly helicopter inspection flights would be flown at elevations as low as 50 ft (15.2 m) above the pipeline throughout the year. The flights may flush birds from their nests, chill eggs, increase nest predation, scatter broods, and decrease nest success for some species. If a 0.25-mile (0.4 km) wide corridor along the pipeline is assumed as the impact zone for a helicopter flying at a 50 ft (15.2 m) elevation, using a mean density of 164 nests per square mile ($64/km^2$) (Table 6.7-2), the number of nest sites affected would be 41 per linear mile (1.6 km) of pipeline through undeveloped tundra. For Alternatives 2 and 3, the number of sites affected would be 390 and 275, respectively. Alternatives 4 and

5 would have 140 and 127 nest sites affected, respectively. The nests closest to the pipeline would be impacted most by helicopter overflights. Overall impacts of helicopter inspection overflights to birds would depend on the sensitivity of the species. Although, impacts on nesting birds would be minor, the USFWS will recommend appropriate measures to avoid or minimize this impact for all avian species, including threatened spectacled eiders.

If onshore pipeline inspection results in the need for summertime repair work during the nesting season, impacts to birds would be greater. If any nests were too close to the work site, disturbance could result in abandonment of nests. Effects would be to nests near the worksite and impacts to birds would be minor.

Abandonment Impacts: Abandonment impacts for Alternatives 2, 3, 4, and 5 would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to birds would be expected to be negligible to minor, and similar to those generated during construction.

6.7.3 Summary of Environmental Consequences

Alternative 1 - No Action Alternative will result in no additional impacts to birds in the project areas. Existing trends in population numbers and productivity will continue without any incremental effects of developing the proposed project. For Alternatives 2, 3, 4, and 5, no significant unavoidable adverse impacts were identified for birds including waterfowl, shorebirds, and seabirds as a result of developing the proposed project. Oil spills could potentially have significant effects on some bird species and are discussed in Chapter 8. In particular, oil spills could potentially affect populations of seaducks, such as oldsquaw, which undergo feather molt in Simpson Lagoon/Gwydyr Bay during the mid summer and migrating king, common, and spectacled eiders. Impact to birds from a spill on land would be considered minor and would affect a relatively small number of birds.

Impacts to birds from project construction are similar in context among Alternatives 2, 3, 4, and 5, although there are differences in project features, such as the amount of habitat affected with each pipeline route. The development of any of these alternatives will result in minor impacts to birds from habitat loss and from the development of the gravel mine at the Kuparuk River Delta. Direct habitat loss for the valve stations pads and the small surface area lost in placement of the VSMs for the pipelines is minor. Impacts to birds from gravel mining and construction of pipelines would be considered negligible due to winter construction. Late melting of ice roads is a minor impact due to habitat loss. Conversely, pipeline VSMs would provide some increase in nesting locations for snow buntings. Other bird species may exhibit some avoidance of the area adjacent to the pipeline. Attraction of seabirds or waterfowl to Seal Island would have a negligible to minor impact on these birds. There is a potential for increased productivity of gulls and ravens from an artificial food source at Seal Island, which could lead to increased predation on other birds.

Helicopter flights between Deadhorse and Seal Island would potentially impact nesting and staging birds within a 1 mile wide (1.6 km) corridor between the two locations. Helicopter inspection overflights of the onshore pipeline routes associated with Alternatives 2 and 3 would also result in disturbance to birds. Transport flight elevations of 200 to 500 ft (61 to 152.4 m), and lower during periods of low visibility and inspection overflights as low as 50 feet (15.2 m), would cause disturbance to nesting birds on the tundra, brood-rearing areas along the coast, molting seaducks in Simpson Lagoon/Gwydyr Bay, and foraging waterbirds in offshore areas. Flights over barrier islands would potentially impact nesting common eiders on each island. The number of flights during construction and operations could potentially affect productivity during one or more seasons of some species, such as oldsquaw and common eiders. Because of the number and timing of offshore helicopter overflights, impacts to common eiders and oldsquaws would be considered significant during construction. Impacts to most other seabirds and sea ducks would be negligible and then minor during operation.

Development of the gravel mine and construction of the onshore pipeline could result in a short-term impact on nesting habitat and a long-term increase in aquatic habitat with the restoration of the mine (a negligible beneficial impact to birds). Operation and maintenance of the pipeline and facilities would have no long-term impacts to birds either onshore or in offshore waters.

The development of any of the project alternatives would require commitment of river bar habitat at the gravel mine and the filling of small areas of tundra for the valve stations. These activities are considered an irreversible commitment of resources. The removal of the pipeline during project abandonment would allow return of the habitat for birds and would not be considered an irreversible commitment.

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6.8 TERRESTRIAL MAMMALS

6.8.1 Affected Environment

The overall density of terrestrial mammals species in the project area is low, similar to other arctic coastal tundra areas. The 21 species that could be found in the project area are listed in Table 6.8-1 (Seaman et al., 1981:70; Jarrell and MacDonald, 1989:1-4).

Populations of microtine rodents are known to undergo large fluctuations in numbers in arctic tundra habitats, affecting birds and mammals preying on them (Feist, 1975:135). Caribou and grizzly bear are the other common mammal species in the project area. Gray wolf, wolverine, red fox, moose, muskox, and coyote occur in small numbers on the Arctic Coastal Plain; however, they are not encountered regularly in the project area (Seaman et al., 1981:70). The species of terrestrial mammals most likely to be affected by the project are caribou, grizzly bear, and Arctic fox.

6.8.1.1 Caribou

Caribou (*Rangifer tarandus*) are one of the dominant terrestrial mammals in the project area. The project area is located within the range of the Central Arctic Herd (CAH), from the Colville River in the west to the ANWR in the east (Figure 6.8-1). The CAH range can overlap with the larger Porcupine Caribou Herd, which ranges farther to the east in ANWR (Cameron and Whitten, 1979:629; Dau and Cameron, 1986:27; Cameron, 1994:35). Local residents have observed that

Table 6.8-1 (page 1 of 1)

Figure 6.8-1 (page 1 of 2)

Figure 6.8-1 (page 2 of 2)

caribou belonging to the Porcupine Herd come as far west as Nuiqsut when a southwesterly wind blows steadily for a week and the weather has been warm; otherwise the herd normally stops near the Sagavanirktok River (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996).

The CAH has been the focus of considerable research since the early 1970s in response to concern about caribou displacement from seasonally important areas of their range due to oil field development (Cameron, 1993:227-231; 1992:7; 1994:1; Cameron and Smith, 1992:2; Cameron et al., 1995:5). Originally, the herd was believed to be a part of the Porcupine Herd (Hemming, 1971:20); however, the herd was discovered later to be a distinct herd based on fidelity to calving grounds and similar movements within the annual cycle (Cameron and Whitten, 1979:630).

The CAH moves northward in the spring from wintering areas in the foothills of the Brooks Range to calve on the Arctic Coastal Plain. Calving occurs on the open tundra from late April to early June (Whitten and Cameron, 1985:35-39). The Arctic Coastal Plain is believed to be used as a calving ground because it has lower numbers of predators and later emergence of mosquitos than the foothills, where there are higher quality food resources available (Cameron and Smith, 1992:8). Calving can occur across the summer range; however, two areas are used consistently for calving by the CAH and are located to the west and east of the project area (Cameron and Whitten, 1979:626-633; Lawhead and Curatolo, 1984:11; Whitten and Cameron, 1985:37) (Figure 6.8-1). These calving areas are: 1) the Kuparuk calving area, west of the Kuparuk River to the Ugnaravik River, 5 to 15 miles (8 to 24 km) south of Milne Point, and north of the Spine Road; and 2) the area west of the Canning River Delta and south of Bullen Point, east of the project area.

The majority of calving occurs within 24 miles (39 km) of the coast (Cameron, 1983:227-231). Little calving occurs within the project area in the Prudhoe Bay oil field between the Kuparuk and the Sagavanirktok Rivers (Pollard et al., 1992:iii; Pollard and Noel, 1996:8). Wetter tundra is believed to be the reason for low calving activity in this area (Whitten and Cameron, 1985:10). Caribou appear to prefer rough ground with some topographic relief for calving, which relates to the diversity of vegetation and biomass of forage species (Nelleman and Cameron, 1996:26). No calving concentrations have been identified along any of the alternative pipeline routes.

The Kuparuk calving area location has changed slightly, with a shift to the west-southwest in 1987 through 1990 in response to construction of the Milne Point Road, which passes through this area (Cameron et al., 1992:13). Cows with calves have been displaced from 0.6 to 1.2 miles (1 to 2 km) of either side the road (Dau and Cameron, 1986:99-100; Cameron et al., 1992:340). This shift of local caribou calving does not appear to have affected regional distribution, since calving still occurs in the Kuparuk area (Johnson and Lawhead, 1989:67-68).

Bulls, yearlings, and non-pregnant cows migrate to the Arctic Coastal Plain, including the project area, from the foothills of the Brooks Range to join cows and newborn calves after calving. The herd reaches its greatest numbers at this time and large aggregations can be found between the Kuparuk River and Oliktok Point and between the Sagavanirktok and Kavik Rivers (Carruthers et al., 1987:426). Post-calving use of the North Slope oil field areas was reported to be higher prior to development of the field

(Child, 1973:4). In recent years, cows with calves appear to avoid oil field areas to some extent (Whitten and Cameron, 1985:37; Dau and Cameron, 1986:99; Cameron, 1992:7-8; Cameron et al., 1995:6). Avoidance of oil field structures by cows with calves has been documented in Kuparuk-area oil fields (Dau and Cameron, 1986:97-100; Cameron and Smith, 1992:8; Cameron, 1992:7), although aerial survey data showed aggregations of caribou during the post-calving period throughout the area (Pollard and Ballard, 1993a:3; Pollard and Noel, 1995:iv). Avoidance of oil field areas could interfere with access to insect relief and foraging areas, affecting weight gain in these animals and, in turn, affecting their reproductive success rate (Cameron 1992:8).

Early summer marks the beginning of the insect season for the caribou, beginning in the foothills and progressing north as temperatures increase. Two groups of insects harass the CAH during summer: the mosquito group (*Aedes* sp.) and the oestrid group, such as warble flies (*Hydroderma trandi*) and the nosebot fly (*Cephenomyia trompe*) (Section 6.6). When these insects are active, they have a profound effect on the behavior and movement of caribou (White et al., 1975:158; Dau, 1986:137-140; Johnson and Lawhead, 1989:30; Lawhead et al., 1994:30).

Searching for relief from insect harassment is the most likely reason for movement of large numbers of caribou through the oil fields toward the coast (Pollard et al., 1992:39). Caribou generally return inland as soon as the temperature drops and mosquito activity lessens (Pollard and Noel, 1994:8). This movement pattern occurs throughout the mosquito season, driven by weather conditions, with caribou moving between insect-relief areas on or near the coast and inland feeding areas (White et al., 1975:158; Roby, 1978:110-116). The best area for insect relief is generally within 0.6 to 1.9 miles (1 to 3 km) of the coast (Dau, 1986:137), because lower temperatures and onshore winds reduce mosquito activity and provide some relief (Pollard and Noel, 1994:44).

Mosquitos emerge in late June, with continued presence in late July. Availability of insect-relief habitat depends on wind and temperature (Lawhead and Curatolo 1984:20). Warm, calm weather increases mosquito activity, resulting in movement of large groups of caribou from inland areas to the coast. Once at the coast, caribou tend to travel in an east to west direction parallel to the coast. In very warm, windless weather, they will even stand chest-deep in coastal waters. Caribou also travel or stand on elevated areas that afford more exposure to the wind (White et al., 1975:158; Roby, 1978:110). Elevated areas include gravel pads and roads within the oil fields (Pollard and Ballard, 1993b:14; Pollard and Noel, 1994:3).

Access to insect-relief areas such as the coast and river deltas is an important factor for caribou summering on the Arctic Coastal Plain, and barriers that obstruct access to these areas could have long-term effects (Cameron and Smith, 1988:2). However, the need for relief from harassment is the overriding factor, and caribou appear to be less affected by human activities or facilities (Shideler, 1986:61). The number of days caribou are harassed by insects (insect harassment days) averages approximately 18 per year (Pollard, 1994:3).

Oestrid flies become the major insect harassment for caribou in late July and August and, as a result, elicit different behavior compared to mosquito harassment (Roby 1978:104). Caribou react to fly harassment by splitting up into smaller groups or individually during this period. In response to flies, caribou usually stand very still with their heads down, listening for flies, then jump or lunge up or side-to-side, toss their heads, run a short distance, and stand with their heads down again. Wind has less effect on reducing fly harassment than mosquitos harassment, and few animals move to the coast and into the project area to get relief from flies (Roby, 1978:111).

Animals begin to disperse out of the project area and move inland into the foothills of the Brooks Range in mid- to late August, coinciding with the late stages of the insect season. Rut begins in October with bulls and cows mixing together in the foothills and southern portions of the Arctic Coastal Plain (Carruthers et al., 1987:425). CAH caribou disperse into relatively small bands that move into the foothills, valleys, and higher slopes on the north side of the Brooks Range in late fall.

Although most caribou spend the winter to the south near the Brooks Range, it is common for several small groups of caribou to spend the winter in the vicinity of the project area (Roby, 1978:70; Carruthers et al., 1987:427). Occasionally, large numbers can be found on the Arctic Coastal Plain in winter (Child, 1973:4).

Total numbers of caribou within the CAH ranged from 6,000 in 1978 to over 23,000 in 1992 (Cameron, 1994:3). The rate of increase has slowed in recent years (Cameron et al., 1995:3) and estimated numbers dropped to 18,100 in 1995 (Wollington - Pers. Comm., 1996). Immigration to and emigration from the adjacent Western Arctic and Porcupine Herds complicate estimates of population size (Carruthers and Jakimchuk, 1986:65; Ballard et al., 1993:21). However, when counts of the CAH in 1995 were made, the herds were separated, and little crossover between herds was suspected (Wollington - Pers. Comm., 1996).

Hunters in Kaktovik have historically testified that there used to be more caribou than today. Potential reasons stated include low-flying small planes and helicopters displacing caribou away from their calving areas and migrating patterns (N. Soloman in USDOI, MMS, 1979:16; J. Ningeok in USDOI, MMS, 1982:28) and development by oil companies in general (I. Akootchook in USDOI, MMS, 1990:10).

6.8.1.2 Arctic Fox

The Arctic fox *(Alopex lagopus)*, a year-round resident of the Arctic Coastal Plain, is a common predator throughout the project area, and has become habituated to the presence of humans and human activities in the North Slope oil fields. Humans provide both artificial food sources (garbage) and denning sites (gravel pads and roads). The Arctic fox is a major predator of eggs and young of waterfowl, shorebirds, and passerines, as well as microtine rodents and Arctic ground squirrels (Eberhardt et al., 1982:188). Any increase in numbers of fox as a result of human activities (i.e., artificial den sites and supplemental food sources) can result in increased predation on their natural prey species (Burgess et al., 1993:1). Fox dens, typically located on widely scattered, dry sites, are more abundant near the North Slope oil fields than in undeveloped areas (Burgess and Banyas, 1993:10), and productivity of Arctic fox at these sites is higher. Food during the summer months is likely the limiting factor to fox population growth, as opposed to the availability of den sites (Burgess and Banyas, 1993:13). Density of fox dens in the central portions of the Arctic Coastal Plain has been recorded at 1 per 18 to 28 square miles (46.6 to 72.5 km^2) (Burgess and Banyas, 1993:12).

6.8.1.3 Grizzly Bear

Grizzly bears (*Ursus arctos)* occur in relatively low densities throughout the Arctic Coastal Plain and in the project area. A total of 28 bears was estimated to occupy the area from the Colville River east to the Shaviovik River and inland to the White Hills in 1994 (Shideler and Hechtel, 1995:32). Home ranges of radio-collared bears in the central Arctic Coastal Plain from 1990 to 1994 were from 1,000 to 2,000 square miles (2,590 to 5,180 km^2). Grizzly bears typically feed on tundra vegetation; however, they are often attracted to oil fields and communities to feed on food waste in dumpsters and landfills. A few radio-collared bears have spent the entire summer within the oil fields, particularly near the NSB landfill (Shideler and Hechtel, 1994:32). A recently installed electric fence at the NSB Landfill has eliminated bear use of this site. Grizzly bears are known to prey on brant and snow goose nests at Howe Island in the Sagavanirktok River delta (Johnson, 1995:3) and will dig up squirrel and fox dens. Denning sites include pingos, raised lake margins, and riverbanks, generally some distance from the project area. However, six dens have been documented within the project area (Shideler and Hechtel, 1994:32).

The grizzly bear population on the Arctic Coastal Plain and in the project area has increased in recent years, (Shideler - Pers. Comm., 1996). Good survival rate of young in recent years is believed to be a factor in this increase, along with the artificial food supply at the NSB landfill. This increase in bear numbers will increase the pressure on prey species, as well as increase the potential for bear-human interactions and bear problems.

6.8.2 Environmental Consequences

The following section describes the potential impacts of each project alternative on terrestrial mammals. The discussion of impacts is organized based on project alternatives as described in Chapter 4. A discussion of impacts from Alternatives 2, 3, 4, and 5 is presented together, as impacts to terrestrial mammals differ only slightly by the landfall of the onshore pipeline. A summary of impacts is presented in Table 6.8-2.

6.8.2.1 Alternative 1 - No Action Alternative

The No Action Alternative would not impact terrestrial mammal species in the project area. Local populations of Arctic fox, grizzly bear, and caribou would be expected to continue current population trends.

6.8.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Development of the mine at the Kuparuk River Delta would result in conversion of 35 acres (14.2 hectares) of river bar to open water habitat. The relatively barren river bar habitat is likely used for insect relief and as a migration corridor by caribou during the mid-summer mosquito season. Grizzly bears also use river bars for travel and hunting ground squirrels, which use dry river banks for burrows. Caribou would likely continue to use the area adjacent to the reclaimed mine site during the insect season when weather conditions afford relief from the insects. Impacts to caribou and other terrestrial mammals from habitat loss are expected to be minor.

Noise disturbance from blasting and heavy equipment at the gravel mine site would be similar to other industrial activities that occur periodically in the project area during winter. Grizzly bears would be denning at this time of the year when gravel would be mined. However, since the general area surrounding the Kuparuk River delta is not known to have grizzly bear denning habitat, no impact to denning grizzly bears from gravel mining is expected.

Arctic foxes are primarily scavengers during the winter and could be attracted to humans and construction activities in search of food. This has the potential to increase the survival rate of these animals during winter months. Even a small increase in the survival rate of foxes in the area can have a direct effect on their prey species, such as nesting waterfowl and shorebirds, during the summer season (Burgess et al., 1993:1). The potential impact of increased survival on their prey species would depend upon the amount of supplemental feeding. Although prevention of scavenging at oil field facilities and construction sites is a goal of industry and agencies, at least some feeding and scavenging is expected to occur.

Table 6.8-2 (page 1 of 2)

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Arctic foxes attracted to construction areas could be injured or killed by vehicles or other construction equipment. In addition, consumption of toxic substances in improperly stored refuse could cause injury or death to foxes. Impacts to foxes would be minor, and impacts on local population numbers are not expected.

Arctic foxes attracted to the island during the winter could become stranded when the ice breaks up in early summer. However, if no food sources were available, animals would not remain for long. Impacts would be similar to those for gravel mining, mainly from attraction to potential food sources. Foxes may become stranded on the island as the ice leaves, and such animals may need to be captured or moved by humans to another location prior to ice leaving. Foxes attracted to Seal Island would comprise a minor impact.

Construction of offshore facilities and slope protection would not be expected to impact other terrestrial mammals. Impacts would occur to individual animals and would not be expected to occur on a level that affects the species population of the project area.

Ice road and onshore pipeline construction activities are scheduled during winter and would create noise and activity and which may displace caribou wintering in the vicinity of the pipeline route. Foraging activity of caribou could be disrupted by this disturbance, but would not last beyond a single winter construction season. Numbers of caribou affected would likely be low since few winter in the project area. Displacement would constitute a minor impact by increasing energy expenditures for individual caribou, but would not be expected to affect caribou survival.

Arctic fox would be affected by disturbances during pipeline construction and would be attracted to the construction area, which would constitute a minor impact. Grizzly bears are not expected to be impacted, because the pipeline routes do not pass suitable denning sites.

Operation Impacts: Winter transportation by vehicles over ice roads and by helicopters is expected to affect Arctic foxes and small numbers of wintering caribou due to noise disturbances (Chapter 9). During summer, freezeup, and breakup, operation activities would include small boats and barges traveling between West Dock and Seal Island, and helicopter traffic between the Deadhorse, Prudhoe Bay, or the Kuparuk airstrip and Seal Island. Only flights from the Kuparuk airstrip would pass over traditional caribou calving concentrations. Grizzly bears usually would not be affected by helicopter traffic due to the elevation of flights and the low density of bears in the general area. Infrequent, low-elevation flights near grizzly bears could result in a disturbance, but this would be short-term. Arctic foxes are not expected to be impacted by helicopter flights, except in the case of low altitude flights. Overall, impacts to terrestrial mammals would be minor.

The pipeline route for Alternative 2 is located within a coastal area used as summer range for the CAH, particularly during the insect-relief season. Pipelines can potentially interfere with caribou movements. North-south movements to coastal insect relief habitat in the onshore project area are currently hampered by the number of low-elevation pipelines that are less than 5 ft (1.5 m) from the ground and numerous roads with traffic present throughout the Prudhoe Bay oil fields (Cameron et al., 1995:6). Traffic on roads is the primary disturbance to cows with calves and other caribou trying to cross pipelines next to the roads (Curatolo and Murphy, 1986:218). Caribou are likely to encounter the new pipeline while traveling eastward along the coast into the prevailing northeast wind (Smith et al., 1994:46; Pollard and Noel, 1994:3). The 150-ft (46 m) set back of the valve station and elevated pipeline from the coast would provide a corridor for unimpeded movement at the coastline. However, for the most part, caribou appear to traverse pipelines easily if they are raised at least 5 ft (1.5 m) and are not adjacent to roads (Curatolo and Murphy, 1986:218).

Alternatives 3, 4, and 5 are primarily aligned along existing pipeline corridors that contain pipelines and roads. Therefore, it is reasonable to assume that these alternatives would not introduce any additional barrier to caribou movements. Alternatives 2, 3, 4, and 5 include VSMs elevating the pipeline at least 5 ft (1.5 m) above ground, a distance that has been found to allow caribou free passage under the pipelines (Cronin et al., 1994:7; Curatolo and Murphy, 1986:23). Other pipeline design features used to minimize impacts to caribou movement include separating new pipeline alignments from adjacent roads, if possible (Cronin et al., 1994:A-57). Roads adjacent to pipelines tend to increase avoidance by caribou (Curatolo and Murphy, 1986:23); however, Alternative 2 does not include an access road adjacent to the pipeline corridors. The proposed gas line from the Central Compressor Plant to the intersection with the oil pipeline would follow existing pipeline corridors and already has two caribou crossings. Existing, congested and low-elevation pipelines presently cause interference with caribou movement; therefore, the new pipeline would not be expected to cause additional interference with movement or avoidance by caribou. Oil and gas pipelines would be placed within existing caribou crossings along the existing road system. Overall, impacts to caribou movement based on the design features and caribou behavior during insect season, would be considered minor.

Oil spills have the potential to affect terrestrial mammals through direct contact from an onshore spill or at shorelines from an offshore spill and from scavenging carcasses. Caribou may ingest oil from contaminated sea ice during the spring since they have been observed using sea ice as a salt lick. Animals that wade through oil could be exposed to inhalation and absorption of toxic hydrocarbon vapors. For Arctic fox, ingestion of oil can result in lethal and sublethal effects, such as changes in the liver and brain, bone marrow depletion, gastrointestinal tract ulcers, inflammation of lungs and nasal passages, and kidney failure. Hair loss or loss of insulating properties due to oiling of the fur could result in severe cold stress (Derocher and Stirling, 1991:56). Any decrease in the insulating quality of fur would have an effect on metabolic rate and, therefore, survival rates.

An oil spill that impacts marine birds or mammals in either nearshore or offshore waters could result in oiled carcasses washing onto area beaches and being scavenged by foxes and bears. Exposure from ingestion by grooming after contacting oil also can occur. There is little information on the effects of oil on grizzly bears; however, ingestion of crude oil by polar bears can result in adverse effects on the kidney, liver, and brain; bone marrow depletion; gastrointestinal tract ulcers; and inflammation of lungs and nasal passages (Oritsland et al., 1981:4). The time of year that an oil spill occurred would be a major factor in assessing which animals would be affected and to what degree. The open water period would be the most vulnerable time for terrestrial mammals because oil would be dispersed over a large area and it would potentially affect the largest number of animals. The impacts of oil on terrestrial mammals are discussed in Chapter 8.

Maintenance Impacts: Winter repair work would have little effect on terrestrial mammals due to the short duration of the activity and low density and scarcity of terrestrial mammals in the project area during winter. During summer months, repairs along the pipeline could cause some temporary disturbance of caribou during the insect season, which would be considered a minor impact. Arctic foxes would likely be drawn to the onshore activity, but otherwise would not be affected. Maintenance of the facilities at Seal Island would have little effect on Arctic foxes during the winter, and foxes would not be present during the open water period. Overall, impacts to Arctic fox would be considered negligible.

An increase in helicopter activities is likely to occur from routine inspections along unroaded portions of the onshore pipeline, particularly for Alternatives 2 and 3. Low-level helicopter flights would disturb grizzly bears and Arctic foxes; however, impacts would be short-term and are considered to be minor. Low-level helicopter inspection overflights would cause a minor impact to caribou from short-term disturbance during the insect season as they move to the coast; however, access to insect relief habitat would not be affected, and impacts would be considered minor.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to terrestrial mammals would be expected to be similar to those generated during construction. Overall impacts would be considered minor.

6.8.3 Summary of Environmental Consequences

No significant unavoidable adverse impacts were identified for terrestrial mammals, including caribou, grizzly bears, and Arctic fox as a result of development of the project.

Alternative 1 - No Action Alternative will result in no additional impact to caribou, grizzly bear, Arctic fox, or other terrestrial mammals in the project area. Existing population numbers and productivity will continue to fluctuate with a range of natural variation.

The development of Alternatives 2, 3, 4, and 5 would result in minor impacts to terrestrial mammals from a small amount of habitat loss in the development of the gravel mine at the Kuparuk River delta, fill for the valve station, and the small surface area lost in placement of the VSMs for the pipelines.

Development of the gravel mine and construction of the onshore pipeline could result in direct short-term displacement of any caribou wintering in the area but impacts of displacement would be minor. Attraction of Arctic fox to construction activities would result in short-term, minor impacts.

Operation and maintenance activities at Seal Island have short-term, negligible impacts on Arctic fox. Low level helicopter overflights associated with routine inspections of portions of Alternative 2 and 3 onshore pipeline routes without road access could disturb grizzly bear, Arctic fox, and caribou. These and impacts from routine onshore maintenance activities would be short-term and are not expected to modify normal movement patterns of these species. These impacts are considered to be minor.

Alternatives 2, 3, 4, and 5 require an irreversible commitment of resources (gravel mine) and, for Alternatives 2, 3, and 4, the filling of small areas of tundra for the valve stations. The removal of the pipeline during project abandonment would allow return of the habitat for terrestrial mammals and would not be considered an irreversible commitment of resources.

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6.9 THREATENED AND ENDANGERED SPECIES

6.9.1 Affected Environment

Four threatened and endangered species occurring in or near the project area are discussed based on requests by the USFWS and the National Marine Fisheries Service (NMFS) (Table 6.9-1). These species are the endangered bowhead whale, threatened spectacled eider, threatened Steller's eider, and delisted Arctic peregrine falcon. Oil tankers traveling from Valdez to refineries along the U.S. Pacific coast may encounter

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other marine mammal, bird, and sea turtle species listed as threatened or endangered. These species are not included in this analysis but are discussed in the Biological Assessment (Appendix B) to be submitted by the lead agency to the USFWS and NMFS to initiate Section 7 consultation under the ESA.

The purposes of the ESA are to conserve ecosystems on which species depend and to provide a program for the conservation of these species. The ESA defines an endangered species as, *"any species which is in danger of extinction throughout all or a significant portion of its range."* The ESA defines a threatened species as one that, *"is likely to become endangered within the foreseeable future."* Threatened and endangered species are those fish, wildlife, or plants listed under Section 4 of the ESA. The following sections summarize the biology of each species including migration, reproduction, and feeding habits.

6.9.1.1 Bowhead Whale (Endangered)

In 1964, the International Whaling Commission (IWC) began to regulate commercial whaling worldwide (Burns et al., 1993:7). The bowhead whale (*Balaena mysticetus*) was listed as a federal endangered species on June 2, 1970 (35 FR 8495). The bowhead gained further protection when the ESA and the Convention on International Trade in Endangered Species of wild flora and fauna were passed in 1973. The bowhead is hunted by natives of the Alaskan Beaufort Sea coast for subsistence. Since 1978, the IWC has imposed a quota on the number of bowheads landed and/or struck by Alaskan natives.

The Bering Sea stock of bowhead whales was reduced greatly by commercial whaling in the late 19th and early 20th centuries, from an estimated original population range of 10,400 to 23,000 (Woodby and Botkin, 1993:403) to a few thousand by about 1910. Shore-based visual surveys conducted at Point Barrow from 1978 through 1983 yielded a population estimate for that period of about 3,500 to 5,300 animals (Zeh et al., 1993:479). Revised estimates of population size, based on visual and acoustic data collected during the 1993 census off Point Barrow, indicate that the most probable size of the 1993 population was 8,200 with a 95% probability that the population was between 7,200 and 9,400 (Zeh, et al., 1996:1). This estimate was recognized by the IWC, and these numbers are in line with recent reports from local Inupiat people (USDOI, MMS, 1983:58-59).

Bowhead whales are seasonal and transient in the Alaskan Beaufort Sea, migrating through from west to east in spring/summer and back in fall (Figure 6.9-1). Most of the bowhead whale population winters along the ice front and in polynyas (irregular areas of open water) of the central and western Bering Sea (Moore and Reeves, 1993:410). Some bowhead whales also move north along the Chukotka Peninsula of Russia (Figure 6-9.1). About April or May, whales begin moving north past St. Lawrence Island and through the Bering Strait into the southern Chukchi Sea, then north through nearshore lead systems to Point Barrow (Moore and Reeves, 1993:336) (Figure 6.9-1). Behavior and timing are fairly consistent with bowheads passing Point Barrow in several "pulses:" the first between late April and early May, a second about mid-May, and a third from late May through early June (Moore and Reeves, 1993:426; A. Brower in USDOI, MMS, 1986a:49; B. Rexford in MBC, 1996:80). Whaling crews have observed that the migrating whales appear to have 'scouts' which check ice conditions in advance of the main migration (Charlie Nauwigewauk, Waldo Bodfish,

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L. Kingik in NSB, 1981:296-297). Whaling crews also have noticed that not all bowhead whales migrate into the Chukchi or Canadian Beaufort Seas, but that some bowheads remain near Barrow in summer (H. Brower, Jr. in USDOI, MMS, 1995c:85).

Most whales move eastward from Point Barrow through offshore lead systems of the central Beaufort Sea (W. Bodfish in NSB, 1981:295). They appear in leads offshore of the Alaskan Beaufort Sea by early May (W. Bodfish in NSB, 1981:295), but apparently do not stop along the spring migration route (V. Nauwigewauk in NSB, 1981:295; A. Oenga in NSB, 1980:182). They arrive in the Canadian Beaufort Sea from about mid-May through mid-June (Figure 6.9-1) (Moore and Reeves, 1993:314). During migration, bowheads may swim under the ice for several miles, and can break through relatively thin ice (approximately 7 inches [18 cm]) to breathe (George et al., 1989:26). The spring migration ends at Herschel Island in the Canadian Beaufort Sea (V. Nauwigewauk in NSB, 1981:295).

Most of the bowhead population is concentrated in the Canadian Beaufort Sea between Herschel Island and Amundsen Gulf during summer (Moore and Reeves, 1993:319). Whales begin moving back westward between late August and early October (Richardson et al., 1987:469-471; Miller et al., 1996:18; I. Akootchook in USDOI, MMS, 1995a:12). The fall migration, extending into late October some years (Moore and Clarke, 1992:29), also seems to occur in pulses, although the pattern is not as clear as the spring migration (Ljungblad et al., 1987:53-54; A. Brower, 1998a:49; Treacy, 1988:39; 1989:15-35; 1990:13-35; Moore and Reeves, 1993:342). These pulses may constitute age segregations with smaller whales migrating earlier, followed by larger adults and females with young. The first pulse has been observed to consist of hundreds of bowheads in "schools like fish" (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:23). These whales are not accompanied by calves (J. Tukle in USDOI, MMS, 1986a:21). The second pulse is thought to consist of females with calves (J. Tukle in USDOI, 1986a:20; T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:22). Fall migration generally occurs south of the pack ice and closer inshore than the spring migration (Moore and Reeves, 1993:342).

Fall surveys conducted in the project area from 1979 through 1995 (Figure 6.9-2) recorded the occurrence of bowheads from the barrier islands to about 75 miles (120 km) offshore, with most sighted 6.2 to 37.2 miles (10 to 60 km) offshore in water depths of 33 to 328 ft (10 to 100 m) (Miller et al., 1996:14-33). Data collected from 1979 to 1995 suggest that bowheads may be present in the project area between approximately August 31 and October 22 (Miller et al., 1996:30). This period is variable depending on ice cover. In light ice years peak numbers of bowheads occurred September 21 through 25, and in heavy ice years peak numbers occurred October 1 through 5 (Miller et al., 1996:30 and 39). The authors of the study found that this difference was not important and may in part be due to the greater difficulty in seeing whales during heavy and moderate ice conditions compared to light ice conditions. Distance of the whales from shore also varied with ice conditions. Mean distance from shore was 18.6 to 25 miles (30 to 40 km) in light ice years and 37.2 to 43.5 miles (60 to 70 km) in heavy ice years (Miller et al., 1996:35). From 1979 to 1986, fall migration was observed to extend over a longer period, and sighting rates were larger and peaked later in the season in years of light ice cover compared to years of heavy ice cover (Ljungblad et al., 1987:136-137; Moore and Reeves, 1993:342).

Bowhead whales apparently take their time returning westward during the fall migration, sometimes barely moving at all, with some localities being used as staging areas due to abundant food resources (W. Bodfish in NSB, 1981:296) or for social reasons (S. Akootchook, USDOI, MMS, 1995a:18). Bowheads take about 2 days to travel from Kaktovik to Cross Island, reaching the Prudhoe Bay area by late September (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:23; A. Oenga, NSB, 1980:182). From Cross Island it takes the whales another 5 days to reach Point Barrow (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:22). Inupiat believe that whales follow the ocean currents carrying food organisms. If the currents go close to Cross Island, whales migrate near there (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:13). In the region immediately east of the project area, bowheads reportedly travel on the inshore side of Cross Island (V. Nauwigewauk in Shapiro and Metzner, 1979:A-II-23). It also has been reported that whales are seen inside the barrier islands near Cross Island practically every year and are sometimes seen between Seal Island and West Dock (F. Long, Jr. - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:14-15). However, aerial surveys from 1980 to 1995 have not documented that bowheads migrate inshore of Cross Island (Miller et al., 1996:3-12). Most aerial surveys are conducted during the fall migration.

Bowhead whales may swim very close to shore on some occasions (B. Rexford in MBC 1996:80; I. Akootchook in USDOI, MMS, 1979:15). Bowheads have been observed feeding not more than 1,500 ft (457 m) offshore in about 15 to 20 ft (4.6 to 6 m) of water (A. Brower in USDOI, MMS, 1979:6; H. Rexford in USDOI, MMS, 1979: 16). Smaller whales may swim in water depths of 14 to 18 feet (4.3 to 5.5 m) (T. Brower, Sr. in NSB, 1980:107). During years when a fall storm pushes ice up against the barrier islands in the Beaufort Sea, bowheads may migrate on the shoreward (lagoon) side of Cross Island, the Midway Islands, and No Name Island. Also, crews looked for whales inside the barrier islands during the years of commercial whaling (T. Brower, Sr. in NSB, 1980:107). Inupiat whaling crews have noticed that whale migration appears to be influenced by wind patterns, moving when winds start up and stopping when they are slow (P. Tukle in USDOI, MMS, 1986b:24). From Point Barrow, whales migrate back southward through the Chukchi Sea to wintering grounds in the Bering Sea (Moore and Clarke, 1992:31-32) (Figure 6.9-1).

Spring-migrating bowhead whales are difficult to survey effectively from the air because usually no well-defined lead system is present east of the Colville River (Moore and Reeves, 1993:319). Therefore, only occasional observations of bowhead whales have been made during spring, usually in small cracks or holes (Moore and Reeves, 1993:317). For example, no bowhead whales were seen within approximately 28 miles (45 km) of the Northstar Unit from April through May, 1979 through 1984 (Moore and Reeves, 1993:318). Bowhead whale observations from spring surveys during 1980 to 1982 are summarized on Figure 6.9-3 (Miller et al., 1996:18-35). These data suggest that bowhead whales do not migrate within 43.5 miles (70 km) of the project area in the spring; however, this conclusion may be unreliable due to the difficulties of seeing whales in pack ice.

In contrast, the fall migration routes in the Alaskan Beaufort Sea have been reasonably well documented. From 1980 to 1995, aerial surveys were conducted by the MMS across the Alaskan Beaufort Sea and near the Northstar Unit during fall migration and suggest that bowhead whales only seldom migrate through or near

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Figure 6.9-3 (page 1 of 2)

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the project area (Figure 6.9-2). Bowhead whales were observed in the Northstar project area on October 6, 1989, when four bowhead whales were seen approximately 6.2 miles (10 km) northwest of Seal Island (Treacy, 1990:B-26). Migrating bowheads were observed within 6.2 miles (10 km) of the northern border of the project area once each in 1980, 1982, 1993, and 1994 (Treacy, 1994:40; Miller et al., 1996:25). During fall 1997, bowheads were observed feeding between Barrow and Prudhoe Bay close inshore near the barrier islands. Early estimates suggested approximately 1,200 individuals were present, but researchers believe that some of the individuals may have been recounted while in feeding areas (S. Treacy - Pers. Comm., 1997).

Fall surveys show that the median water depth at bowhead whale sightings (1982-1995) between 141°W to 146°W longitudes is 138 ft (42 m) (Treacy 1991:53; 1992:55; 1994:65; 1996:55) (Figure 6.9-2). During fall migration, whales are found close inshore east of Barter Island and from Cape Halkett to Point Barrow (Moore and Reeves, 1993:335), generally in water depths less than 164 ft (50 m) (Treacy, 1991:49-53; 1992:55; 1994:65).

Inupiat whalers question the results of aerial censuses of bowhead whales conducted by MMS in the Beaufort Sea. For example, whaling crews sighted 23 bowheads in the Kaktovik region during the fall of 1983 in contrast to five whales sighted by MMS aircraft (J. George, USDOI, MMS, 1983:58-59). Although the fall 1983 MMS aerial surveys were conducted for inshore, mid-offshore, and far-offshore survey blocks (Ljungblad et al., 1984:68), inherent limitations in a sampling survey mean that some animals will be missed. Some limitations of aerial surveys include the fact that planes do not fly in all weather and that submerged bowheads may not be observed due to the speed of the aircraft.

Little is known regarding age at sexual maturity or mating behavior for bowheads. Mating is assumed to occur in late winter and spring (Koski et al., 1993:248), perhaps continuing through the spring migration (Ljungblad, 1981:11-28; Koski et al., 1993:228). Most calves are born from April through early June during spring migration, with a few calves born as early as March or as late as August (Koski et al., 1993:250). Females produce a single calf, probably every 3 to 4 years (Koski et al., 1993:254).

Bowheads are filter-feeders, sieving prey from the water by means of baleen fibers in their mouth. They feed almost exclusively on zooplankton from the water column, with primary prey consisting of copepods (54%) and euphausiids (42%), as indicated from stomach content analyses of whales taken in the Alaskan Beaufort Sea (Lowry et al., 1994:201-238). Other prey include mysids, hyperiid and gammarid amphipods, other pelagic invertebrates, and small fish.

Bowheads feed heavily in the Herschel Islands area in the Canadian Beaufort Sea and Amundsen Gulf area during summer and in the Alaskan Beaufort Sea during fall migration (Figure 6.9-1) (ACS, 1983:27; Ljungblad et al., 1987:53; Lowry, 1993:222). Bowheads generally feed in water depths of less than 164 ft (50 m) in the Canadian Beaufort Sea (Richardson et al., 1987:468-469). In fall surveys conducted from 1979 through 1987, concentrations of feeding bowheads were observed east of Point Barrow and just north of Harrison Bay in late August and early September (Ljungblad et al., 1987:53). The barrier islands all along the coast are considered by local residents as an important resource to the bowhead whale and are used as staging and feeding areas. (M. Pederson in USACE, 1996:51). The summer distribution of bowheads within the Canadian Beaufort Sea is determined primarily by prey density and distribution, which in turn are responsive to variable current and upwelling patterns (LGL and Greeneridge, 1987:2-3).

Bowheads have extremely sensitive hearing (Chapter 9). For example, they can detect sounds of icebreaker operations up to 31 miles (50 km) away (Richardson, 1996:108). It has been suggested that such sensitive hearing also allows whales to use reverberations from their low frequency calls to navigate under the pack ice and locate open water polynyas where they can surface (Ellison et al., 1987:332). Bowheads exhibit avoidance behavior of many manmade sounds, but the range and extent to which they respond to such sounds are variable (Clark and Johnson, 1984:1437-1439).

Generally, the vocalizations of bowhead whales are low, less than 400 Hz frequency-modulated calls, however, their call repertoire also includes a rich assortment of amplitude-modulated and pulsed calls of frequencies up to at least 5 kHz (Wursig and Clark, 1993:176). Calls and songs have been suggested to be associated with different contexts and whale behavior. Observations support the theory that calls are used to maintain social cohesion of groups. For instance, loud frequency-modulated calls were heard as a mother and a calf rejoined after becoming separated during summer feeding (Wursig and Clark, 1993:189). Once the two were together again, calling stopped (Wursig and Clark, 1993:189).

During spring migration off Point Barrow, there have been several instances when individual whales repeatedly produced calls with similar acoustic characteristics (Clark et al., 1987:345). Bowhead whales have been noted to produce signature calls lasting for 3 to 5 minutes each and continuing up to 5 hours (Wursig and Clark, 1993:189). Different whales produce signature calls as they counter call with other members of their herd. It has been suggested that calling among bowhead whales may aid in migration of the herd and that the surface reverberation of the sound off the ice may allow these whales to discriminate among areas through which they can and cannot migrate (Wursig and Clark, 1993:190).

It has been suggested that bowheads are able to locate leads and open water along the marginal ice zone in winter by using acoustics (Moore and Reeves, 1993:353). Although bowheads are morphologically adapted to their ice-dominated environment and can break holes in the ice to breathe, they may use vocalization to assess ice conditions in their path. The intensity of reflected calls is as much as 20 dBs higher from ice floes with deeper keels than from relatively flat, thin ice (Ellison et al., 1987:329).

6.9.1.2 Spectacled Eider (Threatened)

The spectacled eider (*Somateria fischeri*) was listed as a federal threatened species on May 10, 1993 (58 FR 27480). In the summer, this large seaduck is found on the east and west sides of the Bering Sea and along the coasts of the Arctic Ocean. Spectacled eiders are most common in large river deltas such as the Yukon-Kuskokwim, Colville, and Canning Rivers in Alaska (Johnson and Herter, 1989:87).

The Alaskan population of spectacled eiders nests in small numbers, with a discontinuous distribution, over large areas of wet tundra along the coast of Alaska from the Bering Sea north to Barrow and east along the Arctic Coastal Plain into ANWR. The USFWS recognizes two populations of spectacled eiders in Alaska, the Yukon-Kuskokwim Delta population and the Arctic Coastal Plain population (USDOI, FWS, 1996:4). Historically, the Yukon-Kuskokwim Delta had the largest nesting population. Spectacled eiders also nest along the Siberian coast from the Chukotsk Peninsula to the Yana Delta (Johnson and Herter, 1989:87) (Figure 6.9-4). Historical breeding grounds along the Alaskan Beaufort Sea Coast are thought to be near Cape Halkett or Cape Simpson, and in the National Petroleum Reserve, Alaska (Johnson and Herter, 1989:87). Census work in 1993 on the Arctic Coastal Plain indicated that eiders were distributed widely and were most abundant within 37.2 miles (60 km) of the coast between Icy Cape and Barrow (Larned and Balogh, 1994:1). Nesting pairs have been most concentrated in the central Arctic Coastal Plain just west of the Sagavanirktok River in a band including Deadhorse and the ARCO Prudhoe Bay Operations Center (Figure 6.9-5) (Troy, 1995:19). Spectacled eider numbers decrease east of the Shaviovik River (TERA, 1996:9). Aerial surveys in June 1993 reported breeding pairs to be distributed widely throughout most of the Kuparuk and Milne Point oil fields (Figure 6.9-6a & b) (Anderson and Cooper, 1994:20).

A measurable decline in spectacled eider populations was noticed in 1990 (Stehn et al., 1993:264). This decline was especially apparent in the Yukon-Kuskokwim Delta in western Alaska, where the nesting population declined by as much as 96% between 1971 and 1990 (Stehn et al., 1993:271). In the Prudhoe Bay Unit, fewer birds were observed between 1981 and 1991, although the change was not statistically important (Warnock and Troy, 1992:13). This apparent trend was noted to be similar to that occurring in the Yukon-Kuskokwim Delta (Warnock and Troy, 1992:17). Breeding-pair surveys conducted between 1992 and 1996 showed no clear change in the spectacled eiders' breeding population (TERA, 1995:5; Troy - Pers. Comm., 1998:1). In 1993, a total of 9,284 spectacled eiders were observed to be present during surveys on the North Slope (Larned and Balogh, 1994:4).

Molting and wintering areas of spectacled eiders were unknown until recently, when individual birds were tracked by satellite telemetry. Molting spectacled eiders were found in Peard and Ledyard Bays, but could not be well quantified (Larned et al., 1995:1-11). Eiders may molt in a more geographically extensive area (e.g., Mechigmenan Bay in Russia supported approximately 37,000 molting eiders in 1994). Spectacled eiders arrive at the Alaskan Beaufort Sea coast in May from their wintering area and move onto the tundra nesting grounds as freshwater ponds thaw. Soon after breeding, male spectacled eiders leave the tundra ponds for nearshore and offshore waters where they feed for a short period prior to making their southward migration (USDOI, MMS, 1996:III B-13). Females and young remain through late August before beginning their southward migration.

Spectacled eiders usually nest in wet tundra near basin wetland complexes containing open water areas supporting pendant grass (*Arctophila fulva*) or sedges (*Carex* spp.), or near large ponds with emergent pendant grass along the shorelines. Brood-rearing habitat varies from shallow sedge ponds to basin wetland complexes and deep open water lakes (Anderson and Cooper, 1994:1; TERA, 1995:12). Food during the breeding season includes insects such as crane flies (Johnson and Herter, 1989:89).

6.9.1.3 Steller's Eider (Threatened)

The Alaskan breeding population of Steller's eider (*Polysticta stelleri*) was listed as a federal threatened species on June 11, 1997 (62 FR 31748). The historic and current population sizes of the Steller's eider are unknown (62 FR 31748). Steller's eiders may be declining in number range-wide; however, the magnitude of changes in population size are unknown due to the lack of reliable population estimates (62 FR 31749).

The current breeding range of Steller's eider in Alaska includes the Arctic Coastal Plain in northern Alaska west of the Colville River (Figure 6.9-4). In the early 1920s, naturalists described this species as relatively common at several isolated locations on the Yukon-Kuskokwim Delta. Few birds or nests have been found on the Yukon-Kuskokwim Delta in recent years. Three confirmed nests in the Kashunuk River area were found since 1994, of which one successfully hatched (Flint - Pers. Comm., 1998). In 1994 and 1996 through 1998, 1 to 2 nests were located each year on the Yukon-Kuskokwim Delta (62FR31748). Reasons for its decline may include changes in movement patterns and increased mortality, although it is not believed to have been a common nesting bird on the Yukon-Kuskokwim Delta, despite claims made by earlier observers (Kertell, 1991:177-184). There are only three recent records of broods from North Slope locations other than Barrow, Alaska. These include: one in 1997 near the upper Chipp River, approximately 50 miles (80 km) inland from the Dease Inlet/Admiralty Bay area; one in 1993 near Prudhoe Bay; and one in 1987 along the lower Colville River (62 FR 31748).

6.9.1.4 Arctic Peregrine Falcon (Delisted)

The Arctic peregrine falcon (*Falco peregrinus tundrius*) was removed from the federal list of endangered species in 1994 (59 FR 50796); however, the ESA requires the USFWS to continue to monitor the subspecies over a minimum 5-year period. Arctic peregrine falcons nest primarily in the foothills and mountains centered around the upper Colville and Sagavanirktok Rivers, with small numbers nesting in the uplands along other rivers that cross the North Slope (USDOI, FWS, 1982:6). Nests typically are located at least 20 miles (32 km) inland on cliff faces. This subspecies is an uncommon summer visitant and migrant at the Alaskan Beaufort Sea coast, but a fairly common breeder along rivers which drain the north-facing foothills of the Brooks Range (Johnson and Herter, 1989:128). Historically, approximately 150 nesting pairs of Arctic peregrine falcons occurred along the Colville and Sagavanirktok Rivers (USDOI, FWS, 1982:2). A nest was present on a communications tower on Barter Island for several years, although it has not been noted in any publication and the tower is no longer there (Sousa - Pers. Comm., 1997). The decline of this subspecies was caused primarily by contamination with organochlorine pesticides, although egg collecting, human disturbance, and habitat destruction also contributed to the decline (USDOI, FWS, 1982: 5). The likelihood of encountering an Arctic peregrine falcon in the project area is low.

6.9.2 Environmental Consequences

Potential impacts of each project alternative on threatened and endangered species are discussed below. The discussion of impact is organized based on project alternatives as described in Chapter 4. Because the impacts

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Figure 6.9-5 (page 1 of 2)

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Figure 6.9-6a (page 1 of 2)

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Figure 6.9-6b (page 1 of 2)

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for Alternatives 2, 3, 4, and 5 are similar these impacts are discussed collectively and summarized in Table 6.9-2.

6.9.2.1 Alternative 1 - No Action Alternative

No construction is required for a No Action Alternative. The natural variability in population levels and habitat of threatened and endangered species in the Alaskan Beaufort Sea would be undisturbed by a No Action Alternative. Consequently, there would be no impacts to threatened and endangered species.

6.9.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: The bowhead whale, spectacled and Steller's eiders, and Arctic peregrine falcon are not present in the Kuparuk mine site area during the winter, and thus would not be affected by mining activities (Moore and Reeves, 1993:336; Larned et al., 1995:35; Palmer, 1976:8; USDOI, FWS, 1982:7). Approximately 35 acres (14.2 hectares) of sparsely vegetated gravel bar would be removed from the Kuparuk river and converted to deep and shallow open water habitat as a result of gravel mining. This loss of river bar habitat is not expected to create loss of habitat for any of these species. The open-water lake remaining after reclamation of the site may be used by spectacled eiders, but because of its distance from wet tundra, it is unlikely to be used by breeding pairs or broods. Peregrines could hunt other ducks using the lake.

Offshore ice road and other winter construction activities will be completed by the beginning of the bowhead spring migration (late April to early May) (Moore and Reeves, 1993:336). Therefore, no impact to migrating bowheads is expected from winter construction. Summer construction would include island slope protection, pile installation, and island facilities construction. There is no evidence suggesting that construction operations would delay or hinder migratory movements of bowheads; however, local displacement during migration may occur. Any whales that do deviate around a construction area are expected to be displaced to the north, where they may experience heavier ice conditions. However, the magnitude and likelihood of such an offshore displacement is expected to be small relative to the width of the migratory pathway and would be limited to the few months when migration and construction activity coincide. Such avoidance of construction activity is expected to have a minor impact on bowhead whales. The impacts to subsistence from displacement of bowheads are discussed in Section 7.3.2.2.

Transportation requirements associated with these activities would also result in increased noise levels. Most vessel, barge and helicopter traffic during construction would occur between Seal Island and the mainland. Some disturbance, including avoidance of the area by migrating

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whales, is expected from this traffic increase, but the degree of disturbance would depend on the distance of the main migration corridor from the activities between Seal Island and the shoreline. For example, during the years 1979 to 1994, the median distance of the main bowhead migration corridor was 28 to 31 miles (45 to 50 km) from shore, which is 16 to 19 miles (26 to 31 km) from Seal Island. In fall of 1995, the migration corridor was only 19 to 22 miles (31 to 35 km) from shore and 13 to 16 miles (21 to 26 km) from Seal Island (Miller et al., 1996:41). Impacts of noise to bowhead whales resulting from summer construction and vessel traffic are discussed in Chapter 9.

Spectacled eiders are not expected to be affected by winter construction activities at Seal Island because they are absent from the Alaskan Beaufort Sea during the winter. During spring migration and prior to fall migration, male and female spectacled eiders may be impacted both by construction activities at Seal Island and helicopters flying construction materials/personnel to and from the mainland. Post-breeding male spectacled eiders depart Arctic Coastal Plain wetlands approximately June 22 (± 11 days) and stage/migrate offshore a median distance of 4.2 miles (6.7 km) (± 6.9 miles [11 km]) (Petersen, in Bright, 1998:15). Post-breeding spectacled eider females depart Arctic Coastal Plain brood-rearing sites about August 29 (± 10.5 days) and stage/migrate 10.3 miles (16.6 km) (± 10 miles [16.4 km]) offshore. Because post-breeding females are in poor physiological condition, harassment during feeding in these areas may reduce accumulation of fat needed for migration and may have a minor adverse effect on survival. If present, both male and female spectacled eiders could be impacted both by construction activities on Seal Island and helicopter flights to and from the island, and these impacts would be considered minor.

Low-elevation helicopter flights between Deadhorse Airport and Seal Island over tundra nesting areas may flush nesting birds, which may expose eggs to predation and chilling (Gollop et al., 1974:202-232). Multiple flushing events could result in reduced nest success in areas within the helicopter flight paths. The project area supports relatively low densities of eider nests in comparison to other tundra-nesting species (TERA, 1993:9).

Densities of spectacled eider breeding pairs in the Prudhoe Bay area have ranged from 0.21 to 0.49 per square mile (0.08 to 0.19/km^2) from aerial surveys (TERA, 1996:3). Based on the mean density of spectacled eider breeding pairs for the Prudhoe Bay area, a 1-mile (1.6 km) wide flight corridor between the Deadhorse Airport and Seal Island would be expected to overfly approximately 4 to 8 breeding pairs (TERA, 1996:6). Ground surveys have not been systematically conducted along all proposed pipeline routes and helicopter flight corridors. Low-elevation helicopter flights from the Kuparuk airstrip would be expected to affect similar numbers of breeding pairs, based on surveys of that area (TERA, 1996:3). Eiders with broods may be tolerant, to some degree, of noisy human activities, as shown by studies of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that have not demonstrated avoidance of oil field facilities (TERA, 1995:14; TERA, 1996:9). Although spectacled eiders are expected to be within the area affected by aircraft, and nesting eiders could be directly affected, these impacts would be considered minor. However, the USFWS will recommend appropriate measures to avoid or minimize this impact for nesting and brood-rearing spectacled eiders.

Only one Steller's eider nesting site is known within the project area (no Arctic peregrine falcon nesting sites are known) (Federal Register - 62 FR 31748; USDOI, FWS, 1982:6) and any impact to these species from reconstruction of Seal Island would be limited to noise disturbances. Impacts of noise to threatened and endangered species are discussed in Chapter 9.

Aboveground portions of the onshore pipeline would transect eider nesting and brood-rearing areas on the proposed alignment from Point Storkersen to Pump Station No. 1. The area directly impacted by ice roads and pipeline construction is almost entirely moist tundra; few open water ponds are traversed by the construction zone. Such habitat may be traversed by eider broods but is not likely to be used for nesting or brood-rearing. The project area supports low densities of eider nests and broods. Onshore pipeline construction is scheduled to take place in winter when birds are not present; therefore, spectacled eiders will not be directly affected by pipeline construction activities. By the time the birds are selecting nest sites, construction activities on land would be complete. However, slow melting of the construction ice road would likely eliminate this area for nest sites the first year. This indirect effect of construction would be a minor impact since the ice road area constitutes only a small fraction of suitable habitat available to spectacled eiders. Impacts of noise to spectacled eiders are discussed in Chapter 9.

Construction of an elevated pipeline, without an adjacent access road, would help minimize impacts to eider breeding habitat and on movement of broods between nesting and brood-rearing areas. Overall, aboveground pipeline construction would have negligible impacts on eider nesting and brood-rearing habitat along pipeline routes.

Only one Steller’s eider nesting site has been located in the project area in recent years (62 FR 31748). No Arctic peregrine falcons are known to nest in the project area (USDOI, FWS, 1982:6), and ice road construction and onshore placement of the pipeline are not expected to impact these species.

Operation Impacts: Under routine operations, threatened and endangered species would primarily be affected through increased levels of noise from drilling operations, gas-fired turbine generators, and by ship and helicopter traffic to and from the island. Transportation of personnel and supplies during routine island operations would include using trucks on the ice road during winter, helicopters during broken ice seasons (May/June and October/November), and barges during summer. Impacts to migrating bowhead whales from routine island operations would be limited to noise disturbance from industrial noise, tugs, and supply barges, and are considered to be minor. Impacts to subsistence are discussed in Section 7.3.2.2. Minor impacts to spectacled eiders resulting from noise and disturbance from helicopter overflights and inspection of the pipeline along the onshore route could occur. Impacts of noise and disturbance from offshore helicopter overflights and boat traffic would be considered minor. The potential for spectacled eiders to collide with structures on Seal Island is considered a minor impact. However, because mortality resulting from operations could adversely affect this species, the USFWS will recommend appropriate measures to avoid or minimize potential effects. Impacts to Steller’s eiders and Arctic peregrine falcons from routine operations would be from the disturbance of helicopter overflights and would be considered negligible. Impacts to threatened and endangered species from noise are discussed in Chapter 9.

<u>Oil Spills</u>: Oil spills may occur as a result of operations and would present risks to threatened and

endangered species. Potential effects would include direct mortality from oil toxicity, chronic physiological or behavioral changes, destruction of food organisms, and habitat destruction. Oil spills would have the potential to adversely affect threatened and endangered species.

Bowhead Whale: It is difficult to accurately predict the effects of an oil spill on bowhead whales because of a lack of data on the metabolism of this species and because of inconclusive results of examinations of baleen whales found dead after major oil spills (Bratton et al., 1993:736; Geraci, 1990:167-169). Nevertheless, some generalizations can be made regarding impacts of oil on individual whales based on present knowledge. Oil spills that occurred while bowheads were present could result in skin contact with the oil, baleen fouling, ingestion of oil, respiratory distress from hydrocarbon vapors, contaminated food sources, and displacement from feeding areas (Geraci, 1990:181-192). Actual impacts would depend on the extent and duration of contact and the characteristics (age) of the oil (Albert, 1981: 946). Bowhead whales could be affected through residual oil even if they were not present during the oil spill.

Most likely, the effects of oil would be irritation to the respiratory membranes and absorption of hydrocarbons into the bloodstream (Geraci, 1990:184). If oil was concentrated in open water leads, it is possible that a bowhead whale could inhale enough vapors from fresh oil to affect its health. Inhalation of petroleum vapors can cause pneumonia in humans and animals due to large amounts of foreign material (vapors) entering the lungs (Lipscomb et al., 1994:269). It is unclear if vapor concentrations after an oil spill would reach levels where serious effects, such as pneumonia, would occur in bowhead whales. Although pneumonia was not found in sea otters that died after the *Exxon Valdez* oil spill, inhalation of vapors was suspected to have caused interstitial pulmonary emphysema (accumulation of bubbles of air within connective tissues of the lungs).

Available literature on potential oil impacts on whales suggested that a bowhead whale confined to a small, oil-contaminated area would suffer effects to the respiratory system limited to irritation of the mucous membranes and respiratory tract, plus absorption of volatile hydrocarbons into the bloodstream (Bratton et al., 1993:722).

Whales may also contact oil as they surface to breathe, but the effects of oil contacting skin are largely speculative. Bowhead whales have an exceedingly thick epidermis (Haldiman et al., 1985:397). Studies of oil effects on the skin of other cetacean species, such as those summarized by Geraci (1990:182) for four species of toothed whales, may not be indicative of the effects of oil on bowhead whales due to the unique characteristics of their skin. The skin of bowhead whales is characterized by hundreds of rough, skin lesion areas. "These rough areas are variable in size and shape, often 1 to 2 inches (2.5 to 5 cm) in diameter and 1 to 3 millimeters (mm) deep with numerous 'hair-like' projections extending upward 1 to 3 mm from the depths of the damaged skin surface." (Albert, 1996:7). Blood vessels are located just beneath the epidermis of these skin lesions (Albert, 1981:947; Haldiman et al., 1985:391), and large numbers of potentially pathogenic (disease-causing) bacteria have been documented in these areas (Shotts et al., 1990:358). Many of these bacteria produce enzymes that are capable of causing tissue necrosis (tissue death) (Haldiman et al., 1985:397; Shotts et al., 1990:351). The ultrastructural nature of these areas of damaged epidermis has recently been documented (Henk and Mullan, 1996:905-916).

The origin of these rough areas is unknown, but oil is likely to adhere at these sites. Haldiman et al. (1981:648) documented that Prudhoe Bay crude oil adheres to isolated preserved skin samples of bowhead whales and that, "The amount of oil adhering to the surrounding skin and epidermal depression appeared to be directly proportional to the degree of 'roughness' of the [skin]." The authors concluded that these results were, " ... indicative of the possible adherence to the live skin of an active bowhead whale". Oil contacting whale skin may inflame the epidermis, "particularly if the oil is light and aromatic, therefore more reactive" (Engelhardt, 1987:106). This inflammation ultimately may lead to ulcer formation, severe inflammation of the skin and, possibly, blood poisoning (Albert, 1981:948). These findings should be considered when assessing the potential risk to bowhead whales from skin contact with oil (Shotts et al., 1990:358).

Bowhead whale eyes may be particularly vulnerable to damage from oil on the water due to their unusual anatomical structure (Dubielzig and Aguirre, 1981; Haldiman et al., 1981; and Haldiman, 1986). A recent study documented the presence of a large conjunctival sac associated with bowheads' eyes (Dubielzig and Aguirre, 1981; Haldiman et al., 1981; and Haldiman, 1986). The conjunctival sac is a mucous membrane that lines the inner surface of the eyelid and the exposed surface of the eyeball (Zhu, 1997:61). This sac likely aids in providing mobility of the eyeball (Zhu, 1997:62). It has been suggested that if oil gets into the eyes of bowhead whales it would enter the large conjunctival sac and move "inward" 4 to 5 inches (10 to 13 cm) and get "behind" most of the eye (Albert - Pers. Comm., 1997). The consequences of this event are uncertain, but some adverse effects are expected. Detailed study of the anatomy of the bowhead eye (Zhu, 1997) supports speculation that potential impacts of oil on the eyes of bowhead whales would include irritation, reduced vision due to corneal inflammation, and corneal ulceration potentially leading to blindness (Albert, 1981:947; Zhu,1997).

Bowhead whales may ingest oil encountered on the surface of the sea during feeding, resulting in fouling of their baleen plates. It has been noted that baleen whales are vulnerable to ingesting oil when their baleen structures are coated, but the impacts on bowhead whales due to ingestion of oil are unclear (Engelhardt, 1987:108). The baleen plates of bowhead whales are fringed with hair-like projections up to 1 ft (0.6 m) long made of keratin (Lambertsen et al., 1989:29-31). These baleen filaments eventually break off and some are swallowed by the whales (Albert, 1981:950; Albert, 1996:7). Filaments also are often observed tangled into "ball-like" structures while still attached to the baleen of bowheads harvested by Inupiat Eskimos from Barrow (Albert, 1996:7). A laboratory study showed that filtration efficiency of bowhead whale baleen is reduced by 5% to 10% after contact with Prudhoe Bay crude oil (Braithwaite et al., 1983:41). It appeared that when baleen was fouled, viscous crude oil caused abnormal spacing of hairs which allowed increased numbers of plankton to slip through the baleen mechanism without being captured (Braithwaite et al., 1983:42). This loss of baleen filtration efficiency lingered for approximately 30 days. It was uncertain how such reduction would affect the overall health or feeding efficiency of individual whales. In contrast, another study (on baleen of much different structure) concluded that the most severe effects of baleen fouling are short-lived and interfere with feeding to approximately 1 day after a single exposure of baleen to petroleum (Geraci and St. Aubin, 1983:269; 1985:134).

Thick sludge (tar balls) typically appear in the late stages of an oil spill due to increase in the specific gravity of oil as evaporation progresses (Meilke, 1990:11). Anatomical evidence suggests that potential impacts of oil and tar balls on the baleen may be serious. If oil were ingested during feeding, baleen filaments could be sites of oil adherence, as demonstrated by an oil adherence study conducted on bowhead whale baleen in the laboratory (Braithwaite et al., 1983:41). When dislodged, tar balls likely would be swallowed with other food (Albert, 1981:950).

Broken off baleen filaments and tar balls are also of concern because of possible blockage between two parts of the bowhead stomach (1.5 inches [3.8 cm] in diameter) (Tarpley et al., 1987:303), and blockage could pose a major threat to the whale (Albert, 1981:950). Because tar balls may persist in the marine environment for up to 4 years (Meilke, 1990:12), bowhead whales would not have to be present during an oil spill to be affected adversely. Impacts could continue for years. Until definitive experiments are conducted to evaluate the susceptibility of the bowhead feeding apparatus and digestive system to oil pollution, effects of oil ingestion will remain speculative (Lambertsen et al., 1989:125).

It is not known whether bowhead whales can differentiate between hydrocarbon-contaminated and uncontaminated prey (Bratton et al., 1993:723). Cetaceans observed during the *Exxon Valdez* oil spill in Prince William Sound made no effort to alter their behavior in the presence of oil (Harvey and Dahlheim, 1994:263; Loughlin, 1994:366). Following the *Exxon Valdez* oil spill, daily vessel surveys of Prince William Sound were conducted from April 1 through April 9, 1989, to determine the abundance and behavior of cetaceans in response to the oil spill (Harvey and Dahlheim, 1994:263). During the nine surveys, 80 Dall's porpoise, 18 killer whales, and 2 harbor porpoise were observed. Oil was observed on only one individual. It had oil on the dorsal half of its body, and by its labored breathing pattern, appeared stressed. It is probable that bowheads would respond similarly.

Consequences of bowhead whales contacting oil have not been well documented, are largely speculative, and are highly controversial. Geraci (1990:169) reviewed a number of studies pertaining to the physiologic and toxic impacts of oil on whales and concluded, *"*There is no gripping evidence that oil contamination has been responsible for the death of a cetacean*."* A total of 37 cetaceans were found dead during and after the *Exxon Valdez* oil, spill but cause of death could not be linked to exposure to oil (Loughlin, 1994:368). Bratton et al. (1993:721) concluded that petroleum hydrocarbons, *"*Appear to pose no present harm to bowheads*,"* but also noted that this conclusion was less than definitive because of disagreement over the degree of toxicological hazard posed by hydrocarbons.

In contrast, Albert (1981:950) warned that exposure to oil could pose a major threat to bowhead whales based on their anatomy. Bowhead whales are particularly vulnerable to effects from oil spills due to their use of ice edges and leads where released oil tends to accumulate (Engelhardt, 1987:104). Ten criteria for assessing vulnerability to the effects of an oil spill have been developed to aid in impact assessment (Engelhardt, 1987:111-112). This assessment indicated the bowhead whale is vulnerable because the bowhead is an endangered species, any damage to the population could affect species survival (Engelhardt, 1987:111). Individuals are not expected to avoid oil exposure, based on the limited data discussed previously.

Contaminated food sources and displacement from feeding areas also may occur as a result of an oil spill. It is unlikely that the availability of food sources for bowheads would be affected substantially, given the plankton and fish resources available in the Alaskan Beaufort Sea (Bratton et al., 1993:723). The MMS estimated that even if a large oil spill of 160,000 barrels contacted phytoplankton and zooplankton in the Alaskan Beaufort Sea, recovery would be expected to be completed within a week (USDOI, MMS, 1996:IV-M-3). This rapid recovery was anticipated as a result of the wide distribution, large numbers, rapid rate of regeneration, and high fecundity of plankton. Impacts of oil spills on bowhead whales are discussed in Chapter 8.

Eiders: Potential effects of oil on spectacled eiders would include direct mortality from oil toxicity, chronic physiological or behavioral changes, destruction of food organisms, and habitat destruction. Oil removes the water-repellant properties of feathers, causing water to displace the air trapped in and under the plumage, and resulting in hypothermia which eventually kills the bird. Furthermore, buoyancy is lost when this air is displaced, and the bird may sink and drown (Clark, 1984:3). Physiological changes due to ingestion of oil during preening include abnormal conditions in lungs, adrenal gland, kidneys, liver, stomach, and intestines (Clark, 1984:3). Sea ducks, including spectacled eiders, are among the most vulnerable birds, because they often occur in dense flocks and spend much time swimming on the surface. During and after the *Exxon Valdez* oil spill, sea ducks were among the groups which suffered the highest mortality levels (Piatt et al., 1990:387). Impacts of oil spills on this species are discussed in Chapter 8.

Potential effects of oil on Steller's eiders have not been studied; however, it is expected that oil would likely cause adverse effects such as tissue irritation, plumage fouling, and hypothermia. Consumption of oil through contaminated prey or by preening, or inhalation of hydrocarbon vapors, may cause organ damage. Separate or cumulative physiological impacts of oil contamination may result in death. Impacts of oil spills on this species are discussed in Chapter 8.

Peregrine Falcon: The physiological effects of peregrines contacting oil have not been investigated, but effects are likely similar to the effects on spectacled and Steller's eiders. Peregrines may be exposed to oil by capturing oiled prey, which may affect individual falcons. They may also be affected indirectly by an oil spills through reduction in seabirds and shorebirds, their primary prey.

<u>Noise</u>: For bowheads, as with most animals, there is a general tendency for the level of response to manmade noises to scale with the level of variability and unpredictability in the sound source. Animals will show little or no response to a noise source with a relatively constant intensity level and frequency spectrum (e.g., a humming generator, operational drilling platform). Animals will react to a noise source that is rapidly changing in intensity or in frequency content (e.g., an exploration drilling platform, icebreaking activity).

Little is known about the reaction of bowhead whales to unusual or unpredictable noise. However, some insight on the issue can be gained from reviewing the growing traditional and scientific knowledge of bowhead responses to seismic surveys.

There have been various efforts to document the type and level of responses that bowheads have to seismic survey noise. Some have relied on visual observations from an airplane or vessel to look for avoidance response or changes in distribution, and some have included acoustic monitoring to document changes in vocal behavior as well as to measure sound levels at known distances from the seismic activity. In 1984, the MMS supported a study during which bowhead groups were observed for up to several hours prior to the operation of a seismic vessel and then during the approach of that vessel while operating its seismic array. Obvious responses were noted. Some animals responded when the vessel was less than 6 miles (9.7 km) away, and one group showed strong avoidance at a distance of 3.1 miles (5 km) from the operating seismic vessel (Ljungblad et al., 1985:45). The most obvious responses of bowheads to the approach of the vessel were changes in dive and surface behaviors, which occurred at ranges of up to 6 miles (9.7 km). When seismic operations were within 1 mile (1.6 km) of the whales, they swam rapidly away from the vessel. Interpretation of these results in terms of bowhead response range to seismic vessels when surveys were being conducted is complicated by a lack of control data since other seismic vessels were operating during all phases of the experiments. Therefore, the maximum distance out to which whales were observed consistently responding should be considered the minimum range within which responses occur. Results of the study were presented to the IWC Scientific Committee in 1984, which, after review, recommended that additional research be conducted and the results of the 1984 study be subjected to rigorous re-analysis.

There are important recent results indicating that bowheads respond to seismic operations. Acoustic call counts from bottom-mounted recorders operating during the 1996 Northstar Unit season indicate that bowhead call rates change depending upon the range from the seismic operation and whether seismic activities were occurring or not occurring. Bowhead call rates from the bottom-mounted recorder operating closest to the seismic operation were lower during hours with seismic operations than during hours without, while call rates from the recorder furthest from the seismic activity were more than twice as high when seismic activity occurred than when it did not occur (Richardson et al., 1998: 3-7). These results suggest that some bowheads diverted offshore when passing the project area when seismic activity occurred or that some bowheads decreased their calling rates. Aerial survey data from 1996 and 1997 further suggest that bowhead whales avoid areas with seismic operations (Richardson et al., 1998: 5-59 to 5-63). When the 1996 and 1997 aerial data were combined, all of the 52 sightings noted during seismic activity and within 3.5 hours after seismic activity, were greater than 12 miles (20 km) from the activity. The consistency between these results based on two different methods (acoustic and aerial survey) lend strong credibility to the conclusion that whales are displaced by seismic activity.

Analysis of the bowhead sightings (179 whales) from the aerial surveys during BPXA's 1996 and 1997 seismic programs indicate that those programs did not greatly influence the position of the migration corridor (Richardson et al., 1998:5-58). However, the power of this conclusion is limited by the small number of bowhead sightings during seismic activity (8 whales) or within 3.5 hours of seismic activity (13 whales).

Whaling crews have noted that seismic surveys conducted near Barrow, Cross Island (Nuiqsut), and Kaktovik have been responsible for altering migration patterns and for failures in harvesting success. Unsuccessful harvesting seasons have been found to closely correlate with seismic survey activities (T. Napageak in USDOI, MMS, 1995b:13; B. Adams in USDOI, MMS, 1995c:26; H. Brower, Jr. in USDOI, MMS, 1995c:84; B. Rexford in MBC, 1996:80). The extent of the migration pattern displacement has required hunting to be performed at least 10 miles (16 km) further offshore than would be the case without seismic survey activities (E. Brower, in USDOI, MMS, 1995c:29-30; T. Albert, in USDOI, MMS, 1995c:41); however, migration patterns are believed to change at distances of 35 miles (56 km) from seismic source vessels and to shift the migration path as much as 30 miles (48 km) from the normal migratory path (17 Whalers in MBC, 1997:Attachment C).

Although quantitative estimates are not available, in all likelihood, seismic survey sounds are among the loudest of any industrial noise source; and are the most ubiquitous industrial noise source. They introduce more total sound energy into the arctic water than any other industrial noise source. Furthermore, a seismic survey impulse is a sound with enough acoustic energy to cause physical harm to a marine mammal ear (Ketten, 1992; Ketten et al., 1993). Bowhead whales are possibly the most sensitive to seismic survey sounds because their hearing is expected to be the most sensitive for the band of frequencies (i.e., 100 to 400 Hertz) that can propagate to the greatest ranges. However, this does not necessarily mean that bowheads are the species most susceptible to biological impact.

Although BPXA's proposed project does not include seismic surveys, information on whale reactions to seismic noise is relevant in a general way. Recent data on seismic noise transmission and bowhead responses to seismic operations in the Northstar Unit area have come from monitoring efforts carried out as part of the 1996 and 1997 BPXA Seismic Survey Project (Richardson, 1997, 1998). These results show that no whales were seen within 11 miles (21 km) of the seismic site during active seismic periods, but numerous whales were seen 1.2 to 12.4 miles (2 to 20 km) of the site during periods without seismic activity (Richardson, 1998:5-60 to 5-62). Richardson (1998) concluded that these results suggest that bowheads avoid waters near seismic operations. Traditional Knowledge of bowhead hunters includes strong impressions about the reactions of bowheads to seismic survey activities (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MS, 1995:84; B. Rexford in MBC, 1996:80; E. Brower in USDOI. MMS, 1995:41; 17 Whalers in MBC, 1997: Attachment C).

No studies on the effects of noise on spectacled eiders have been conducted. It can only be inferred from studies of distribution of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that spectacled eiders have not demonstrated avoidance of oil field facilities or high noise areas (TERA,, 1995:14; TERA, 1996:9). TERA (1995:10-11) noted that at "... the present stage of understanding it is difficult to formulate defensible hypotheses as to what would be expected regarding what spectacled eiders would do in the absence of facilities, largely because of the uncertainty as to what constitutes brood rearing habitat." TERA (1995:11) also noted that "...qualitatively, the movements documented for our marked broods (6 broods) do not suggest avoidance of facilities or obstacles to movements." However, it is of importance to note that noise and activity may result in avoidance of facilities whether or not they pose obstacles to brood movement (TERA, 1995:11-12).

Spectacled eiders appear to tolerate some degree of noise from industrial sources throughout the Prudhoe Bay region. Most broods observed in the Prudhoe Bay area spent part of their time within 656 ft (200 m) of high-noise production facilities, and some broods were located near Deadhorse airport (TERA, 1996:IV). Ground surveys of spectacled eiders within 1,640 ft (500 m) of the Kuparuk and Milne Point oil field facilities showed eiders to be present at an average distance of 722 to 732 ft (220 to 233 m) from oil field facilities, with one pair as close as 32.8 ft (10 m) (Anderson and Cooper, 1994:24). Anderson and Cooper (1994:58) noted that spectacled eiders were widely distributed in the Kuparuk and Milne Point oil fields, but were not abundant at any single location. However, there were inherent weaknesses in this study, including observer bias in detecting eider nests and observing eiders at the outer boundary of 1,640 ft (500 m). During the brood-rearing period, eiders with broods were also found to move extensively through the region and did not appear to avoid high noise areas (TERA, 1995:7-9). Anderson (1992) reported potential avoidance by spectacled eiders of the GHX-1 facility at Prudhoe Bay (as cited in TERA, 1995:12). However, the area supports low densities of eider nests and broods, ranging from 0.34 to 0.57 nests/square mile (0.13 to 0.22/km^2) (TERA, 1995:5), based on aerial and ground surveys conducted from the Kuparuk Rivers to the Sagavanirktok River, an area of approximately 463.3 square miles (1,200 km^2) (TERA, 1995:1-2). Measurable effects of noise from the project are unlikely and, therefore, are considered negligible (Chapter 9).

There are no data available on the impacts of noise on Steller's eider. Given the similarities in ecology between this species and the spectacled eider, it is possible that both species show similar responses to industrial noise. Impacts of noise from the project are considered negligible (Chapter 9).

Maintenance Impacts: Both planned and unplanned pipeline maintenance activities associated with operations would take place year-round over the expected 15-year life of the project. Planned maintenance of the offshore segment would not entail excavation; therefore, impacts are considered to be negligible to threatened and endangered species. The degree of impact to threatened and endangered species from unplanned maintenance and repair would vary depending on the nature of the problem, season, and approach used to uncover/rebury the pipe and to perform repairs. These impacts are expected to be short-term and limited to the area that requires maintenance. During open water season, the magnitude of effects would vary depending on the extent of required repairs and the method used to excavate the pipeline and conduct repairs.

Low-level helicopter pipeline inspection overflights would occur weekly throughout the year, including the nesting and brood-rearing period during the summer. These activities could disrupt nesting, molting, foraging, and brood-rearing spectacled eiders. Disruptions caused by helicopter noise would depend on the flight elevations, which are anticipated to be as low as 50 ft (15.2 m). Disruption of nesting or brood-rearing activities within a 0.25-mile (0.4 km) wide corridor could affect productivity of nearby nests. The highest number of breeding pairs documented along the pipeline route for Alternatives 2 and 3 are six pairs each (TERA, 1996:3; TERA, 1996:Figure 4; TERA, 1997:Figure 4). Maximum documented spectacled eider pairs along routes for Alternatives 4 and 5 are only 2 nests (TERA, 1996:3; TERA, 1996:Figure 4; TERA, 1997:Figure 4). Because impacts from inspection overflights under all alternatives could have a minor impact on nesting and brood-rearing spectacled eiders adjacent to onshore pipeline corridors, the USFWS will recommend appropriate measures to avoid or minimize potential effects.

If onshore pipeline inspection results in the need for summertime repair work, impacts to spectacled eiders in the area would be of longer term than the inspections themselves. Birds may become used to the repair activity or they may avoid the area. If a nest were close enough to the work site, disturbance could result in abandonment of the nest. This would be a concern only for work during a 6- to 8- week period in June and July when the birds are present (Johnson and Herter, 1989:89; TERA, 1996:7). Effects to nests could affect populations of spectacled eiders nesting in the oil fields. Effect of pipeline maintenance and repairs in the summer on spectacled eiders would depend on the proximity of the activity to eider nests or broods. Because the activity could decrease the productivity or survival of spectacled eiders along the pipeline corridor, the impact would be considered minor. However, the USFWS will recommend appropriate measures to avoid or minimize potential effects.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to threatened and endangered species would be expected to be similar to those generated during construction and would be negligible to minor. Abandonment activities conducted during the winter would not impact threatened and endangered species because these species are absent from the area during winter. However, if abandonment activities at Seal Island occurred during the spring and fall migration of bowhead whales it is likely that they would be disturbed by noise from the activities. The effects of noise to bowhead whales is discussed in Chapter 9.

6.9.3 Summary of Environmental Consequences

Alternative 1 - No Action Alternative would result in no impact to the bowhead whale and to the Steller's eider and the spectacled eider. Existing population numbers and productivity would continue to fluctuate with a range of natural variation. With the exception of an oil spill, no significant unavoidable adverse direct impacts from the proposed project (Alternatives 2, 3, 4, and 5) were identified for the endangered bowhead whale.

Alternatives 2, 3, 4, or 5 (project development) would have similar impacts on these threatened and endangered species. Ice road construction and Seal Island reconstruction would not impact bowheads or eiders because these activities would occur in winter. Operational and maintenance activities, and drilling at Seal Island would create noise which might be heard by bowheads several miles away from Seal Island. Impacts of such noise on bowheads may include a change in migratory behavior as whales pass by the project area. Actual impact to the whales from the sound is considered minor and would only last during project operation. Construction and abandonment would occur in the winter. In addition, spectacled and Steller's eider would not be expected to be impacted by noise at Seal Island.

Staging and/or post-breeding spectacled eiders in the offshore waters during the open water period could be affected by extensive helicopter traffic between the mainland and Seal Island during the construction phase. Low-elevation inspection flights of the onshore pipelines during the nesting season could affect productivity of spectacled eider nests near the pipeline. Collision with vertical structures at Seal Island could result in injury or mortality of migrating spectacled eiders. Late melting of ice roads following construction can delay the availability of tundra habitat the following season. However, nest site loss due to late melting ice roads would have a minor impact, because of the abundance of suitable nesting habitat in the project area. Impacts to spectacled eiders from oil spills would be considered significant (see Section 8.7.2.7).

After abandonment of the project, there would be no further impacts to these endangered or threatened species.

The development of the four action alternatives require the commitment of a gravel resource and the filling of small areas of tundra for the valve stations resulting in an irreversible commitment of resources. Irretrievable commitments of resources for this project such as material used for constructions of the facilities would not be expected to impact the bowhead whale, spectacled eiders, or Steller's eider.

6.9.4 References

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- Joseph Kaleak
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TABLE 6.3-1
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON PLANKTON AND MARINE INVERTEBRATES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	N/A	None anticipated.	None anticipated.
Ice Roads – Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island – Construction	Once	3 Months	Plankton: Local in waters adjacent to Seal Island. Marine Invertebrates: Within the island footprint.	Negligible - To phytoplankton from temporary increase in turbidity due to gravel placement; to plankton and marine invertebrates due to propwash from tugs and dewatering discharges at Seal Island. Minor - To zooplankton and marine invertebrates from temporary increase in turbidity due to gravel placement; to marine invertebrates in soft substrate and hard-bottom communities from burial, trenching/ backfilling, installation of island slope protection system, displacement, and increased turbidity.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Plankton: Waters adjacent to Seal Island. Marine Invertebrates: On the island slopes.	None - From island discharges. Minor - To benthic communities from disturbance due to maintenance/repair of island, resulting in temporary losses of numbers at repair locations.	None anticipated.
Offshore Pipeline – Construction	Once	3 Months (Winter)	Temporary disturbance of 21.4 to 36.7 acres (8.7 to 14.9 hectares) of benthic habitat depending on alternative.	Minor - To plankton and marine invertebrates from habitat loss due to disturbance, burial, and plume from spoils on melting ice; from loss in production of epontic community and other marine invertebrates.	None anticipated.
Offshore Pipeline – Operation/ Maintenance	Rare	15 years	Waters adjacent to area requiring maintenance activity.	Negligible - To plankton and marine invertebrates, depending upon maintenance activities, a temporary loss of benthic invertebrates would occur at the maintenance site.	None anticipated.

TABLE 6.3-1 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON PLANKTON AND MARINE INVERTEBRATES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline – Construction	Once	6 Months (Winter)	Habitat loss of benthic habitat for Alternative 5.	None anticipated.	None anticipated.
Onshore Pipeline – Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None anticipated.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine water areas contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Mortality of individuals contacted resulting in temporary (few days) reduction in population numbers in the affected area.	None anticipated.
Abandonment	Once	3 to 6 Months	Hard bottom community on island slopes.	Minor - To plankton and marine invertebrates from impacts similar to those from construction; to hard bottom community from loss of habitat on island slopes.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable

TABLE 6.4-1
COMPOSITION OF FISH SPECIES CAUGHT IN NEARSHORE WATERS
1985-1994 Endicott Fish Monitoring Studies

Common Name	Scientific Name	Inupiaq Name	Total Catch[1]	Percent
Anadromous/Amphidromous				
Arctic cisco	*Coregonus autumnalis*	*Qaaktaq*	805,241	11.8
Least cisco	*Coregonus sardinella*	*Iqalusaaq*	277,699	4.1
Char	*Salvelinus* sp.	*Iqalukpik*	149,811	2.2
Broad whitefish	*Coregonus nasus*	*Aanaakliq*	141,297	2.1
Rainbow smelt	*Osmerus mordax*	*Ilhuagniq*	105,569	1.5
Humpback whitefish	*Coregonus pidschian*	*Pikuktuuq*	7,040	0.1
Hybrid cisco	*Coregonus* sp.	*Aanaakliq*	437	<0.1
Pink salmon	*Onchorhynchus gorbuscha*	*Amaqtuuq*	244	<0.1
Chum salmon	*Onchorhynchus keta*	*Iqalugruaq*	29	<0.1
Bering cisco	*Coregonus laurettae*	*Qaaktaq*	2	<0.1
Freshwater				
Ninespine stickleback	*Pungitius pungitius*	NIR	22,086	0.3
Round whitefish	*Prosopium cylindraceum*	*Aanaakiq*	17,380	0.3
Arctic grayling	*Thymallus arcticus*	*Sulukpaugaq*	6,478	0.1
Burbot	*Lota lota*	*Tittaaliq*	97	<0.1
Threespine stickleback	*Gasterosteus aculaetus*	NIR	89	<0.1
Slimy sculpin	*Cottus cognatus*	*Kanayuk*	50	<0.1
Marine				
Arctic cod	*Boreogadus saida*	*Iqalugaq*	4,410,172	64.4
Fourhorn sculpin	*Myoxocephalus quadricornis*	*Kanayuk*	658,804	9.6

TABLE 6.4-1 (Cont.)
COMPOSITION OF FISH SPECIES CAUGHT IN NEARSHORE WATERS
1985-1994 Endicott Fish Monitoring Studies

Common Name	Scientific Name	Inupiaq Name	Total Catch[1]	Percent
Marine (Cont.)				
Arctic flounder	*Liopsetta glacialis*	*Natagnak*	204,048	3.0
Saffron cod	*Eleginus navaga*	NIR	26,415	0.4
Capelin	*Mallotus villosus*	*Pagmaksraq*	8,267	0.1
Snailfish	*Liparis* sp.	NIR	5,197	0.1
Pacific herring	*Clupea pallasi*	*Uksiuktuuk*	233	<0.1
Great sculpin	*Myoxocephalus polycanthocephalus*	*Kanayuk*	42	<0.1
Pacific sandlance	*Ammodytes hexapterus*	NIR	26	<0.1
Wolf-eel	*Annarhichthys ocellatus*	NIR	14	<0.1
Starry flounder	*Platichthys stellatus*	*Natagnak*	6	<0.1
Prickleback	*Stichaeidae*	NIR	5	<0.1
Rock gunnel	*Pholis gunnelus*	NIR	3	<0.1
Kelp greenling	*Hexagrammos decagrammus*	NIR	3	<0.1
Eelpout	*Zoarcidae*	NIR	2	<0.1
Alaska plaice	*Pleuronectes quadrituberculatus*	NIR	1	<0.1
Lumpsucker	*Cyclopteridae*	Kaviksuak	1	<0.1

Notes: 1 = During 1985-1994, out to water depths of 9.8 feet (3 m) deep
NIR = No information received
sp. = Species

Source: Fechhelm et al., 1995:7; Webster and Zibell, 1970:1-277

TABLE 6.4-2
RELATIVE ABUNDANCE OF COMMON SPECIES FROM DIRECTIONAL FISH TRAP CATCHES IN GWYDYR BAY COMPARED TO THE OVERALL ENDICOTT STUDY AREA

Species	Gwydyr Bay [1] (percent)	Endicott Total [2] (percent)
Arctic cisco	8.0	12.5
Least cisco	17.1	4.3
Broad whitefish	2.0	2.2
Char	4.5	2.3
Arctic cod	41.7	68.4
Fourhorn sculpin	26.8	10.2

Sources: 1 = Compiled from: Cannon et al., 1987:Appendix B
2 = Compiled from: Fechhelm et al., 1995:7

TABLE 6.4-3
FISH SPECIES CAUGHT BY VARIOUS SAMPLING PROGRAMS, NORTHSTAR UNIT AND ADJACENT OFFSHORE AREAS

Location	Water Depth	Type of Sampling	Common Name	Scientific Name	Catch	Percent	Reference
Eastern Chukchi and Western Beaufort Sea	130-1,300 ft (40-400 m)	Bottom trawl	Arctic cod	*Boreogadus saida*	227	35	1
			Canadian eelpout	*Lycodes polaris*	121	19	
			Twohorn sculpin	*Icelus bicornis*	74	11	
			Hamecon	*Artediellus scaber*	36	6	
			Arctic Alligatorfish	*Aspidophoroides olriki*	36	6	
			Snailfish	*Liparis* sp.	34	5	
			Leatherfin lumpsucker	*Eumicrotremus derjugini*	29	4	
			Fish doctor	*Gymnelis viridis*	27	4	
			Spatulate sculpin	*Icelus spatula*	20	3	
			Slender eelblenny	*Lumpenus fabricii*	11	2	
			Eelpout	*Lycodes raridens*	10	2	
			Arctic staghorn sculpin	*Gymnocanthus tricuspis*	5	1	
			Fourline snakeblenny	*Eumesogrammus praecisus*	4	<1	
			Ribbed sculpin	*Triglops pingeli*	3	<1	
			Saddled eelpout	*Lycodes mucosis*	3	<1	
			Threespot eelpout	*Lycodes rossi*	2	<1	
			Polar cod	*Arctogadus glacialis*	1	<1	
			Stout eelblenny	*Lumpenus medius*	1	<1	
			Daubed shanny	*Lumpenus maculatus*	1	<1	
Pingok Island	33-46 ft (10-14 m)	Otter trawl	Arctic cod	*Boreogadus saida*	47	30	2
			Fourhorn sculpin	*Myoxocephalus quadricornis*	43	28	
			Spotted snailfish	*Liparis callyodon*	63	41	
			Wattled eelpout	*Lycodes palearis*	1	<1	

TABLE 6.4-3 (Cont.)
FISH SPECIES CAUGHT BY VARIOUS SAMPLING PROGRAMS, NORTHSTAR UNIT AND ADJACENT OFFSHORE AREAS

Location	Water Depth	Type of Sampling	Common Name	Scientific Name	Catch	Percent	Reference
Stump Island	6.5-33 ft (2-10 m)	Small mesh otter trawl	Arctic cod	*Boreogadus saida*	592	93	3
			Fourhorn sculpin	*Myoxocephalus quadricornis*	14	2	
			Slender eelblenny	*Lumpenus fabricii*	2	<1	
			Arctic cisco	*Coregonus autumnalis*	2	<1	
			Pacific sandlance	*Ammodytes hexapterus*	8	1	
			Snailfish	*Liparis* sp.	10	2	
			Capelin	*Mallotis villosis*	10	2	
East of West dock	0-40 ft (0-12 m)	Small mesh otter trawl	Arctic cod	*Boreogadus saida*		98	4
			Kelp snailfish	*Liparis tunicatus*		<1	
			Fourhorn sculpin	*Myoxocephalus quadricornis*		<1	
			Pacific sandlance	*Ammodytes hexapterus*		<1	
			Capelin	*Mallotis villosus*		<1	
			Rainbow smelt	*Osmerus mordax*		<1	
			Least cisco	*Coregonus sardinella*		<1	
North of West dock at 0.6, 1.8, 3, and 4 miles (1, 3, 5, and 7 km)	13-30 ft (4-9 m)	Surface tow net	Cod larvae	*Gadid species*	8096	64	5
			Capelin larvae	*Mallotus villosus*	3762	30	
			Arctic cod	*Boreogadus saida*	315	2	
			Snailfish larvae	*Liparid* sp.	278	2	
			Sculpin larvae	*Cottid* sp.	130	1	
			Ninespine stickleback	*Pungitius pungitius*	11	<1	
			Arctic cisco	*Coregonus autumnalis*	8	<1	
			Sandlance	*Ammodytes hexapterus*	2	<1	
			Least cisco	*Coregonus sardinella*	1	<1	

TABLE 6.4-3 (Cont.)
FISH SPECIES CAUGHT BY VARIOUS SAMPLING PROGRAMS, NORTHSTAR UNIT AND ADJACENT OFFSHORE AREAS

Location	Water Depth	Type of Sampling	Common Name	Scientific Name	Catch	Percent	Reference
North of West Dock	6.5-30 ft (2-9 m)	Surface tow net	Arctic cod	*Boreogadus saida*	5246	80	6
			Capelin	*Mallotus villosus*	710	11	
			Arctic cisco	*Coregonus autumnalis*	413	6	
			Kelp snailfish	*Liparis tunicatus*	126	2	
			Sculpins	*Cottid* sp.	20	<1	
			Nine-spine stickleback	*Pungitius pungitius*	16	<1	
			Arctic flounder	*Liopsetta glacialis*	5	<1	
			Eelblenny	*Lumpenus* sp.	4	<1	
Boulder Patch and Narwhal Island	20-40 ft (6-12 m)	Under-ice winter sampling using gill, trammel, or trap nets	Arctic cod	*Boreogadus saida*	80	84	2
			Snailfish	*Liparis* sp.	15	16	

Notes: ft = feet
m = meters
sp. = Species

Sources: 1 = Frost and Lowry, 1983:3
2 = Craig and Haldorson, 1981:437, 454
3 = Tarbox and Spight, 1979:2-11
4 = Moulton and Tarbox, 1987:45
5 = Dames and Moore, 1989:6 (Stations 21-24)
6 = Thorsteinson et al., 1991:149-151

TABLE 6.4-4
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON MARINE AND FRESHWATER FISH

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	N/A	None – To freshwater fish from use of freshwater to construct/complete ice roads.	None anticipated.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Footprint of island and surrounding waters.	Negligible to Minor - To marine fish from displacement and temporarily increased turbidity from gravel placement and dewatering plume.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Approximately the island footprint.	Negligible - To marine fish from displacement and maintenance activities. Beneficial - To marine fish from increased habitat diversity as a result of hard substrate of island slope protection.	Potential long-term beneficial impact from increased habitat diversity.
Offshore Pipeline - Construction	Once	3 Months (Winter)	6 to 9 miles (9.7 to 14.5 km) of pipeline route.	Negligible – To marine and anadromous fish from temporary displacement and temporary loss of habitat; from seafloor alterations. Minor - To marine fish from burial of pipeline under floating ice causing avoidance of area.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Short lengths of pipeline route.	Minor - To marine and anadromous fish from noise and from temporary displacement during potential offshore pipeline repairs, resulting in avoidance of area.	None anticipated.

TABLE 6.4-4 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON MARINE AND FRESHWATER FISH

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline - Construction	Once	6 Months (Winter)	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	Individuals, from creation of 35-acre (14 hectare) lake.	None - To freshwater and anadromous fish.	Beneficial – To freshwater and anadromous fish following site rehabilitation due to creation of additional overwintering habitat.
Large Oil Spill	Rare	Unknown	Marine and fresh water areas contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Mortality of marine and anadromous fish as a result of oil toxicity effects from physiological or behavorial changes, destruction of food organisms, and habitat damage.	None anticipated.
Abandonment	Once	3 to 6 Months	Island and pipeline area.	Minor - To marine and freshwater fish similar to offshore construction.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable

TABLE 6.5-1
MARINE MAMMALS OF THE BEAUFORT SEA

Common Name	Scientific Name	Inupiaq Name[1]
Bowhead whale	*Balaena mysticetus*	*Agviq*
Beluga whale	*Delphinapterus leucas*	*Qilalugaq*
Gray whale	*Eschrichtius robustus*	*Agvigluaq*
Ringed seal	*Phoca hispida*	*Natchiq*
Bearded seal	*Erignathus barbatus*	*Oogruk*
Spotted seal	*Phoca largha*	*Qasigiaq*
Pacific walrus	*Odobenus rosmarus*	*Aiviq*
Polar bear	*Ursus maritimus*	*Nanuq*

Notes: 1 = From Webster and Zibell, 1970; SRB&A and ISER, 1993

TABLE 6.5-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON MARINE MAMMALS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	Polar Bears: Individuals. Ringed Seals: Less than 35 expected to be displaced in the vicinity of the construction area.	Negligible – To bearded seals from displacement due to noise. Minor - To polar bear from construction activities, resulting in attraction to site or displacement of individuals; to ringed seals from construction noise, resulting in displacement of less than 35 seals within the corridor.	None anticipated.
Ice Roads - Operations	Annually	All winter	Polar Bears: Individuals. Ringed Seals: Less than 35 expected to be displaced in the vicnity of the ice road.	Negligible – To bearded seals from displacement due to noise. Minor - To polar bears from noise and activities, resulting in attraction to site or displacement of individuals; to other marine mammals from noise, resulting in displacement.	None anticipated.
Island - Construction	Once	3 Months	Polar Bears: Individuals. Ringed Seals: Less than 12 expected to be displaced in the vicnity of the construction area.	Minor - To polar bears from disturbance of and attraction to construction activities; to ringed seals displaced due to noise from island reconstruction and would affect less than 12 seals.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Individual marine mammals.	Minor - To ringed seals in winter if open water lead formed and entrapped seals; to marine mammals due to noise disturbance from island activities, resulting in temporary displacement of some animals; to some polar bears from possible attraction.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	Polar Bears: Individuals. Ringed Seals: Less than 35 expected to be displaced in the vicnity of the construction area.	Negligible - To bearded seals from noise disturbance resulting in displacement of seals. Minor - To polar bears from construction activities resulting in attraction to site or displacement of individuals; to ringed seals from construction noise, resulting in displacement of less than 35 seals.	None anticipated.

TABLE 6.5-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON MARINE MAMMALS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Short length of pipeline route.	Negligible - To marine mammals from noise disturbance during planned pipeline maintenance. Minor - To marine mammals from noise and activities during unplanned maintenance resulting in limited avoidance of the area by a few individuals.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	Within a few hundred feet of mining activity.	None – To whales and seals. Minor – To polar bears from noise disturbance resulting in abandonment of a den.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine waters and ice contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Potential mortality of beluga whales, not normally present in the areas likely to be contacted by oil; mortality of seals from direct contact with oil, consumption of oiled prey, injection during grooming, inhalation of vapors. Significant – Mortality of polar bears from ingestion of oil during grooming, consumption of oiled prey, or loss of insulation and subsequent hypothermia. A major oil spill(s) or the cumulative effects of many small spills, could have negative population effects for polar bears.	Minor - Disturbance to marine mammals from spill response activities and noise. Also, disturbance from icebreaking barge activities during broken/thin ice conditions may occur even though an oil spill has not.(icebreaking barge activities are not expected to coincide with the fall bowhead migration past the project area).
Abandonment	Once	3 to 6 Months	Island and pipeline area.	Negligible to Minor - To marine mammals from noise disturbance activities, would be similar to construction.	None anticipated.

Notes: km = Kilometers N/A = Not applicable

TABLE 6.6-1
COMMON PLANT SPECIES OF TUNDRA VEGETATION TYPES
IN THE PROJECT AREA

Major Type	Community	Common Species	Scientific Name
Dry Tundra	Prostrate shrub/crustose lichen	Entire-leaf avens Curly sedge Black oxytrope	*Dryas integrifolia* *Carex rotundata* *Oxytropis nigrescens*
	Dwarf shrub/crustose lichen (cryoturbation)	Purple braya Shining alkali grass Entire-leaf mountain avens Arctic willow Net-veined willow Purple Mountain Saxifrage	*Braya purpurasens* *Puccinellia andersonii* *Dryas integrifolia* *Salix arctica* *Salix reticulata* *Saxifraga oppositifolia*
	Dry dwarf shrub/forb barrens (sand dunes)	Fescue grass Sea lyme-grass Sweet-flowered rock jasmine Round leaf willow Northern wormwood Fisher's tundra grass	*Festuca* sp. *Elymus arenaria* *Androsace chamaejasmine* *Salix ovalifolia* *Artemesia borealis* *Dupontia fisheri*
	Dry forb /grass barrens (barrier islands)	Sea lyme-grass Creeping alkali grass Oyster leaf Sea beach sandwort	*Elymus arenarius* *Puccinellia phryganodes* *Honckenya peploides* *Mertensia maritima*
Moist Tundra	Moist sedge/dwarf shrub	Narrowleaf cottongrass Fragile-seed sedge Bigelow's sedge Arctic willow	*Eriophoryum angustifolium* *Carex mertensii* *Carex bigelowii* *Salix arctica*
	Moist tussock sedge/ dwarf shrub	Tussock cottongrass Narrowleaf cottongrass Entire-leaf avens Arctic willow Net-veined willow Laborador tea	*Eriophorum vaginatum* *Eriophoryum angustifolium* *Dryas integrifolia* *Salix arctica* *Salix reticularis* *Ledum decumbens*
Wet Tundra	Wet graminoid tundra	Russet sedge Loose-flowered sedge Water sedge Russet's cottongrass Narrowleaf cottongrass Curly sedge	*Carex saxitalis* *Carex rariflora* *Carex aquatilis* *Eriophorium russoleum* *Eriophorium angustifolium* *Carex rotundata*
	Wet saline tundra	Sea-beach sandwort Oysterleaf Hoppner's sedge Creeping alkali grass Bear sedge Low starwort Common scurvy grass	*Honkeney peploides* *Mertensia maritima* *Carex subspathacea* *Puccinellia phryganodes* *Carex ursina* *Stellaria humifusa* *Cochlearia officinalis*
Aquatic Tundra	Aquatic sedge-grass tundra	Marsh marigold Bladderwort Narrowleaf cottongrass Scheuchzer's cottongrass Water sedge	*Caltha palustris* *Utricularia vulgaris* *Eriophorum angustifolium* *Eriophorum scheuchzeri* *Carex aquatilis*
	Aquatic grass tundra	Pendant grass	*Arctophila fulva*

Source: Walker et al., 1980

TABLE 6.6-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON COASTAL VEGETATION AND INVERTEBRATES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	Alt. 2 - 262.7 acres (106.3 hectares) Alt. 3 - 235 acres (95.1 hectares) Alt. 4 - 180 acres (72.8 hectares) Alt. 5 - 163 acres (66 hectares)	Minor – To tundra vegetation from delayed snow/ice melt and compressed vegetation for a couple of years after initial construction.	Disturbance of coastal vegetation and invertebrates could affect nesting bird habitat.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	N/A	None anticipated.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	N/A	None anticipated.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	N/A	None anticipated.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15-years	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	Less than 2 acres (0.8 hectares) of tundra habitat for entire pipeline route.	Minor – To coastal vegetation and invertebrates in project area from placement of VSMs and gravel pads.	Disturbance of coastal vegetation and invertebrates could affect nesting bird habitat.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Depends on required activity.	None – To coastal vegetation and invertebrates from operations or planned inspections and maintenance activities. Minor - To coastal vegetation and invertebrates from offroad vehicles during summer unplanned maintenance and emergency repair activities, if needed.	None anticipated.

TABLE 6.6-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON COASTAL VEGETATION AND INVERTEBRATES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	Loss of 35 acres (14 hectares) of sparsely vegetated river bar habitat.	Minor - From the loss of river bar habitat.	None anticipated.
Large Oil Spill	Rare	Unknown	Few hundred yards of tundra for onshore spills; coastline areas contacted by oil for offshore spills - up to 200 miles (322 km) from the release site.	Minor - Damage to tundra/coastal vegetation, with recovery potentially taking up to 5 years. Significant – Mortality of freshwater invertebrates; potential long-term impact to various invertebrate life stages due to contamination of sediments.	Significant – Damage to sensitive coastline vegetation from oil spill response activities.
Abandonment	Once	3 to 6 Months	Alt. 2 - 262.7 acres (106.3 hectares) Alt. 3 - 235 acres (95.1 hectares) Alt. 4 - 180 acres (72.8 hectares) Alt. 5 - 163 acres (66 hectares)	Minor - Similar to ice road and onshore pipeline construction.	None anticipated.

Notes: Alt. = Alternative
km = Kilometers
N/A = Not applicable

TABLE 6.6-3
COMPARISON OF TUNDRA TYPES IMPACTED BY ICE ROAD FOOTPRINTS FOR ALTERNATIVES 2, 3, 4, AND 5

Tundra Type	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Moist Tundra	82.7 acres (33.5 hectares)	65 acres (26.3 hectares)	45 acres (18.2 hectares)	32 acres (13 hectares)
Wet Tundra	97 acres (39.2 hectares)	109 acres (44.1 hectares)	91 acres (36.8 hectares)	89 acres (36 hectares)
Aquatic Tundra	80 acres (32.3 hectares)	41 acres (16.6 hectares)	32 acres (13 hectares)	32 acres (13 hectares)
Dry Tundra	3 acres (1.2 hectares)	1 acre (0.4 hectares)	1 acre (0.4 hectares)	1 acre (0.4 hectares)
Saline Tundra	None	19 acres (7.7 hectares)	11 acres (4.4 hectares)	9 acres (3.7 hectares)
Total Acreage	262.7 acres (106.3 hectares)	235 acres (95.1 hectares)	180 acres (72.8 hectares)	163 acres (66 hectares)

Note: Width of ice roads is 130 feet (39.6 meters)

TABLE 6.7-1
BIRDS WHICH COULD OCCUR IN THE PROJECT AREA

Common Name	Scientific Name	Inupiaq Name[1]
Red-throated Loon	*Gavia stellata*	*Qagsraupiagruk*
Pacific Loon	*Gavia pacifica*	*Malgik*
Yellow-billed Loon	*Gavia adamsii*	*Tuullik*
Common Loon	*Gavia immer*	*Malgi*
Short-tailed Shearwater	*Puffinus tenuirostris*	NIR
Pelagic Cormorant	*Phalacrocorax pelagicus*	NIR
Sandhill Crane	*Grus canadensis*	*Tatinqaq*
Northern Shoveler	*Anas clypeata*	*Aluutaq*
Tundra Swan	*Cygnus columbianus*	*Qugruk*
Greater White-fronted Goose	*Anser albifrons*	*Niglivialuk*
Lesser Snow Goose	*Chen caerulescens*	*Kanuq*
Pacific Black Brant	*Branta bernicla*	*Niglingaq*
Canada Goose	*Branta canadensis*	*Iqsragutilik*
Northern Pintail	*Anas acuta*	*Ivugaq*
Lesser Scaup	*Aythya affinis*	*Gaqutuuq*
Common Eider	*Somateria mollissima*	*Amauligruaq*
King Eider	*Somateria spectabilis*	*Qinaluk*
Spectacled Eider	*Somateria fischeri*	*Tuutalluk*
Oldsquaw	*Clangula hyemalis*	*Aaqhaaliq*
White-winged Scoter	*Melanitta fusca*	*Uvinnuagayuuk*
Surf Scoter	*Melanitta perspicillata*	*Tuungaagruk*
Steller's Eider	*Polysticta stelleri*	*Igniqauqtuq*
Golden Eagle	*Aquila chrysaetos*	*Tinmiaqpak*
Northern Harrier	*Circus cyaneus*	NIR
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	*Kirgavik*
Gyrfalcon	*Falco rusticolus*	*Kirgavik*
Short-eared Owl	*Asio flammeus*	*Nipaiuktaq*
Snowy Owl	*Nyctea scandiaca*	*Ukpik*
Willow Ptarmigan	*Lagopus lagopus*	*Nasaullik*
Rock Ptarmigan	*Lagopus mutus*	*Niksaaktuniq*
Semi-palmated plover	*Charadrius semipalmatus*	*Kurrakurak*
Black-bellied Plover	*Pluvialis squatarola*	*Tulikpak*
Lesser-Golden Plover	*Pluvialis dominica*	*Tullik*

TABLE 6.7-1 (Cont.)

BIRDS WHICH COULD OCCUR IN THE PROJECT AREA

Common Name	Scientific Name	Inupiaq Name[1]
Ruddy Turnstone	*Arenaria interpres*	*Tulligauraq*
Semipalmated Sandpiper	*Calidris pusilla*	*Livilivillaqpak*
Western Sandpiper	*Calidris mauri*	NIR
White-rumped Sandpiper	*Calidris fuscicollis*	NIR
Baird's Sandpiper	*Calidris bairdii*	*Puviaqtuuyaaq*
Pectoral Sandpiper	*Calidris melanotos*	*Puviaqtuuq*
Dunlin	*Calidris alpina*	*Siyyukpaligauraq*
Stilt Sandpiper	*Calidris himantopus*	NIR
Buff-breasted Sandpiper	*Tryngites subruficollis*	*Satqagiilaq*
Long-billed Dowitcher	*Limnodromus scolopaceus*	*Siyukpalik*
Red-necked Phalarope	*Phalaropus lobatus*	*Auksrauk*
Red Phalarope	*Phalaropus fulicaria*	*Auksrauk*
Pomarine Jaeger	*Stercorarius pomarinus*	*Isunnagluk*
Parasitic Jaeger	*Stercorarius parasiticus*	*Migiaksaayuk*
Long-tailed Jaeger	*Stercorarius longicaudus*	*Isunnak*
Glaucous Gull	*Larus hyperboreus*	*Nauyak*
Glaucous-winged Gull	*Larus glaucescens*	*Nauyak*
Ross' Gull	*Rhodostethia rosea*	*Nauyak*
Arctic Tern	*Sterna paradisaea*	*Mitqutailaq*
Common Murre	*Uria aalge*	*Atpak (Atpa)*
Thick-billed murre	*Uria lomvia*	*Atpatuuq*
Black Guillemot	*Cepphus grylle*	*Inagiq*
Savannah Sparrow	*Passerculus sandwichensis*	*Akitchiaksraq*
Lapland Longspur	*Calcarius lapponicus*	*Putukkiuluk*
Hoary Redpoll	*Carduelis hornemanni*	*Saksaknik*
Common Raven	*Corvus corax*	*Tulugak*
Snow Bunting	*Plectrophenax nivalis*	*Amautligauraq*

Notes: 1 = From Webster and Zibell, 1970; SRB&A and ISER, 1993
NIR = No information received

TABLE 6.7-2
NEST AND BREEDING SEASON DENSITIES IN THE POINT MCINTYRE REFERENCE AREA, 1981 TO 1992

Species	Average Nest Density (Number/km^2)	Average Breeding Season Density (Individuals/km^2)
Red-throated Loon	0.1	0.19
Pacific Loon	1.5	2.35
Greater White-fronted Goose	1.1	3.15
Canada goose	0.1	0.25
Northern Pintail	0.1	2.73
King Eider	1.3	3.31
Spectacled Eider	0.2	0.26
Oldsquaw	1.3	5.25
Willow Ptarmigan	0.1	0.26
Rock Ptarmigan	0.3	1.16
Black-bellied Plover	0.6	1.14
Lesser Golden Plover	2.7	7.48
Ruddy Turnstone	0.1	0.39
Semipalmated Sandpiper	12.5	29.52
Western Sandpiper	0.1	0.13
White-rumped Sandpiper	0.6	2.59
Baird's Sandpiper	0.7	0.91
Pectoral Sandpiper	8.7	30.94
Dunlin	7.5	18.78
Stilt Sandpiper	0.7	1.88
Buff-breasted Sandpiper	0.9	4.71
Long-billed Dowitcher	0.4	4.11
Red-necked Phalarope	0.9	6.87
Red Phalarope	6.8	13.4
Parasitic Jaeger	0.1	2.29
Lapland Longspur	14.8	59.99

Notes: km^2 = Square kilometer

Source: TERA, 1993b:9, 18

TABLE 6.7-3
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON BIRDS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	In the immediate vicinity of onshore ice roads.	Negligible – No/few birds present during winter construction.	Negligible – To non-territorial birds Minor – To territorial birds due to temporary nesting habitat loss caused by slow melting of onshore ice roads covering tundra.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Area flown over by helicopters between airport and Seal Island.	Negligible – No/few birds present during winter construction; due to helicopter overflight to/from island on most seabirds and seaducks; to seabirds and waterfowl that may have gathered near/on island during installation of facilities, concrete mats/grading of submerged gravel berm, and sealift. Minor – Small boat/barge disturbance of resting, molting, feeding, and staging waterfowl; helicopter overflight disruption of nesting, feeding, molting, intake/storage of energy needed for fall migration, and staging (e.g., brant, king eiders, and surf scoters). Significant – Disturbance to molting oldsquaw and common eiders from helicopter overflights.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Seal Island area and all areas between island and boat launch or airport.	Negligible – Due to helicopter overflight to/from island on most seabirds and seaducks other than brant, oldsquaw, common eiders, and surf scoters; to seabirds and waterfowl that may have gathered near/on island during repair/maintenance of concrete mats/submerged gravel berm.	Beneficial – Sea ducks and phalaropes (small number) may feed on/near shoreline of island. Minor – Lingering of birds due to possible open water near island in early winter.

TABLE 6.7-3 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON BIRDS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Island – Operation/ Maintenance (Cont.)	Annually	15 years	Seal Island area and all areas between island and boat launch or airport.	Negligible to Minor – Potential increase in gull and raven population due to artificial food resources; resulting predation of other bird species. Minor – Small boat/barge disturbance of resting, molting, feeding, and staging waterfowl; helicopter overflight disruption of nesting, feeding, molting, intake/storage of energy needed for fall migration, and staging (e.g., brant, oldsquaw, king and common eiders, and surf scoters); flight and attraction hazard to birds (including during migration) due to island structures, lighting, and gas flare.	None anticipated.
Offshore Pipeline – Construction	Once	3 Months (Winter)	6 to 9 miles (9.7 to 14.5 km) of pipeline route.	Negligible – No birds expected offshore during winter construction.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Short length of pipeline route.	Negligible – No expected disturbance of birds during planned operations/maintenance.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	Less than 2 acres (0.8 hectares) of tundra habitat.	Negligible – No/few birds present during winter construction. Minor – Habitat loss due to shoreline transition gravel pad (Alternatives 2, 3, and 4) and VSMs.	Beneficial impact - nesting opportunities in/near newly disturbed ground close to onshore pipeline/VSMs and on VSM support members.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	In the immediate vicinity of onshore ice roads.	Negligible – Normal planned maintenance scheduled to avoid bird interaction. Negligible to Minor – Avoidance of pipeline and gravel pads by some tundra-nesting shorebirds. Minor – Unplanned pipeline maintenance/repair during summertime could result in local disruption of nesting with possible abandonment; due to low altitude helicopter inspection flights over pipeline disrupting nesting (including flushing and chilling/predation of eggs/young).	None anticipated.

TABLE 6.7-3 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON BIRDS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Gravel Mining Construction Operation	Once Occasionally	3 Months (Winter) Unknown	35 acres (14 hectares) of gravel bar.	Negligible – No/few birds present during winter mining activities. Minor – To birds from loss of gravel bar habitat.	Negligible – Beneficial use of reclaimed mine site for waterfowl resting and feeding.
Large Oil Spill	Rare	Unknown	Marine waters, lagoons, and tundra areas contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Mortality of waterfowl and shorebirds in onshore aquatic habitats due to direct contact with oil if a spill occurred during the summer. Significant - Mortality of birds in marine waters or lagoon areas due to direct contact with oil if a spill occurred during openwater period.	Minor – Disruption of nesting or staging activities from spill response activities.
Abandonment	Once	3 to 6 Months	Island and pipeline route.	Negligible to Minor - To birds from disturbance similar to island pipeline construction.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable
VSM = Vertical support member

TABLE 6.8-1
TERRESTRIAL MAMMALS WHICH COULD OCCUR IN THE PROJECT AREA

Common Name	**Scientific Name**	**Inupiaq Name** [1]
Barren-ground Shrew	*Sorex ugyanak*	*Ugrugnaq*
Tundra Shrew	*Sorex tundrensis*	*Ugrugnaq*
Dusky Shrew	*Sorex monticolus*	*Ugraugnaq*
Arctic Ground Squirrel	*Spermophilus parryii*	*Siksrik*
Brown Lemming	*Lemmus trimucronatus*	*Avannapiaq*
Collared Lemming	*Dicrostonyx groenlandicus*	*Qilagmiutaq*
Northern Red-backed Vole	*Clethrionomys rutilus*	*Avinnaq Pamiuqturuaq*
Tundra Vole	*Microtus oeconomus*	*Avinnaq*
Singing Vole	*Microtus miurus*	*Avinnaq*
Arctic Hare (Alaska hare)	*Lepus othys (othus)*	*Ukialliq*
Gray Wolf	*Canis lupus*	*Amaguq*
Coyote	*Canis latrans*	*Amaguuraq*
Arctic Fox	*Alopex lagopus*	*Tigiganniaq*
Red Fox	*Vulpes vulpes*	*Kayuqtuq*
Grizzly Bear	*Ursus arctos*	*Aklak*
Ermine/Short-tailed Weasel	*Mustela erminea*	*Itigiaq*
Least Weasel	*Mustela nivalus*	*Nauyaluk*
Wolverine	*Gulo gulo*	*Qavvik*
Caribou	*Rangifer tarandus*	*Tuttu*
Moose	*Alces alces*	*Tuttuvak*
Muskox	*Ovibos moschatus*	*Uminmaq*

Notes: 1 = From Webster and Zibell, 1970

TABLE 6.8-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON TERRESTRIAL MAMMALS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	In the immediate vicinity of onshore ice roads.	Minor - To Arctic fox behavior from disturbance and attraction to construction activity; to overwintering caribou due to disturbance and displacement from foraging areas.	None anticipated.
Ice Roads - Operations	Annually	All winter	N/A	Minor - To Arctic fox due to increased injury and death from vehicle collisions; to overwintering caribou from disturbance and displacement of foraging areas.	None anticipated.
Island - Construction	Once	3 Months	Area flown over by helicopters between airport and Seal Island.	Minor - To Arctic fox from disturbance and attraction to construction activity.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Seal Island area and all areas between island and boat launch or airport.	Negligible - To Arctic fox from attraction to operation and maintenance activities. Minor - To Arctic fox from stranding and attraction to food sources at Seal Island; to Arctic fox, grizzly bear, and caribou as a result of low-elevation helicopter overflights.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	6 to 9 miles (9.7 to 14.5 km) of pipeline route.	Minor - To Arctic fox from attraction to construction areas.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Short length of pipeline route.	Negligible - To Arctic fox attracted to winter operation/maintenance activities.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	Less than 2 acres (0.8 hectares) of tundra habitat.	Minor - To low numbers of overwintering caribou from construction activities, resulting in temporary displacement from foraging areas; to Arctic fox from attraction to construction activities.	None anticipated.

TABLE 6.8-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON TERRESTRIAL MAMMALS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	In the immediate vicinity of onshore ice roads.	Minor - To Arctic fox, caribou, and grizzly bear due to repairs and inspections (low-level helicopter overflights) causing temporary displacement; to caribou movement toward insect-relief habitat during summer.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	Loss of 35 acres (14.2 hectares) of habitat.	None - To denning grizzly bears. Minor - To caribou from loss of insect relief habitat; to Arctic fox due to increased injury and death from vehicle collisions; to Arctic foxes and grizzly bears due to habitat loss.	None anticipated.
Large Oil Spill	Rare	Unknown	Tundra or shorelines contacted by oil - up to 200 miles (322 km) from the release site.	Minor - Potential mortality of individual Arctic foxes or grizzly bears from loss of fur insulative value; ingestion of oil during grooming or consumption of oiled carcasses; to individual caribou through absorption and inhalation of vapors.	Negligible - Displacement of animals from hazing or cleanup activities, reduction of prey species, and displacement of caribou from oiled vegetation areas.
Abandonment	Once	3 to 6 Months	Island and pipeline route	Minor - To Arctic fox, caribou, and grizzly bear, similar to construction.	None anticipated.

Notes: km = Kilometers

TABLE 6.9-1
THREATENED AND ENDANGERED SPECIES,
ALASKAN BEAUFORT SEA/NORTH SLOPE

Common Name	Scientific Name	Present Status
Bowhead whale	*Balaena mysticetus*	Endangered
Spectacled eider	*Somateria fischeri*	Threatened
Steller's eider	*Polysticta stelleri*	Threatened
Arctic peregrine falcon	*Falco peregrinus tundrius*	Delisted

TABLE 6.9-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON THREATENED AND ENDANGERED SPECIES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	N/A	None – Threatened and endangered species not present during the winter.	Minor - To spectacled eiders from delayed availability of potential tundra nest sites.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Area flown over by helicopters between airport and Seal Island.	None - To bowhead whales if major construction activities are completed by spring migrations. Minor – To bowhead whales from noise and activities from summer construction resulting in migratory path deflection; to spectacled eiders due to helicopter overflights causing displacement of nesting birds resulting in exposure of eggs to chilling and loss of eggs due to predation; disturbance of molting eiders could lead to expenditure of excess energy needed for fall migration; disturbance to staging/ migrating eiders from barge traffic between the mainland and Seal Island.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Seal Island area and all areas between island and boat launch or airport.	None - To bowhead whales if maintenance activities completed before migrations. Negligible – To peregrine falcons and Steller's eiders from helicopter overflights. Minor – To bowhead whales from noise and activities from maintenance activities; to spectacled eiders due to helicopter overflights; disturbance to staging/ migrating eiders from barge traffic between the mainland and Seal Island; from potential collisions with structures on Seal Island.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	N/A	None – Threatened or endangered species not present during the winter construction period.	None anticipated.

TABLE 6.9-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON THREATENED AND ENDANGERED SPECIES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Length of offshore pipeline route.	Negligible – To threatened and endangered species from planned maintenance activities; to peregrine falcons and Steller's eiders from helicopter overflights. Minor – To bowhead whales from noise and activities from vessel traffic; to spectacled eiders from helicopter and boat traffic.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	Less than 2 acres (0.8 hectares) of tundra habitat.	None – Steller's eiders and Arctic peregrine falcons not present during winter construction or likely to nest in project area. Negligible – To spectacled eiders from loss of nesting and brood-rearing habitat.	Minor – Temporary loss of nesting habitat from delayed ice road melting following construction.
Onshore Pipeline – Operation/ Maintenance	Weekly	15 years	In the immediate vicinity of onshore pipeline.	Negligible – To Steller's eiders and peregrine falcons from noise disturbance from helicopters. Minor – To spectacled eiders from helicopter overflights; to threatened and endangered species from unplanned, summer maintenance and repair.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None – Threatened and endangered species not present during winter activities; no habitat loss expected.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine waters, lagoons, and tundra areas contacted by oil - up to 200 miles (322 km) from the release site.	Minor – To Steller's eider (few found in project area) from contact with oil or ingestion of oil contaminated food. Significant – Mortality of spectacled eiders from contact with oil along shorelines or in the lagoon areas during migration or from ingestion of oil contaminated food; injury and/or mortality of bowhead whales from an oil spill contacting coincident with migration.	Minor - Disruption of bowhead whale migration from noise and boat traffic related to cleanup, displacement of birds from habitats and disruption of nesting activities from oil spill response.
Abandonment	Once	3 to 6 Months	Island and pipeline route.	Negligible to Minor – Impacts similar to those for construction activities.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable

CHAPTER 7.0

AFFECTED HUMAN ENVIRONMENT AND IMPACTS

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7.0 AFFECTED HUMAN ENVIRONMENT AND IMPACTS

7.1 INTRODUCTION

Chapter 7 presents the environmental setting and potential impacts of each alternative on the human environment. Aspects of the human environment addressed include: subsistence harvesting, cultural/ archaeological resources, land and water uses, socioeconomics, transportation, aesthetics, and recreation. Information in this chapter also supports decisions on local zoning and master plan revisions, Coastal Zone Consistency review, rights-of-way and land use permits, and Historic Preservation Act Section 106 clearance.

The human environment in the vicinity of the Northstar Unit is described in Chapter 7. Potential impacts on the human environment associated with the construction, operation, maintenance, and abandonment of each project alternative are also described. The criteria used to determine if an impact on the human environment is potentially significant were developed based on the National Environmental Policy Act (NEPA) definition of significance, which requires consideration of context (as it affects society as a whole, the affected region, the affected interest, and the locality) and intensity or severity of the impact. The range of intensity included none (no impact), negligible, minor, and significant as defined in Section 1.8. The analysis of intensity considered the magnitude of the impact, the geographic extent, duration and frequency, and the probability of an impact occurring. Professional expertise and judgement were used to determine if an impact was significant. Significant impacts would require either avoidance, minimization, or demonstration that the impact are unavoidable. The text highlights design, construction, or operational features of each alternative that are principally responsible for identified impacts, or that will substantially reduce impacts that might otherwise occur.

Chapter 7 addresses the following issues related to the project's potential impacts on the human environment:

Issues/Concerns	Section
· How would the bowhead whale harvest be affected by construction activities?	7.3.2
· How would boating around Seal Island be restricted?	7.3.2
· How would construction of the onshore pipeline affect caribou migration patterns and calving areas?	7.3.2
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Issues/Concerns	Section
· What would be the expected revenues to the NSB?	7.6.2
· How much money would be spent in Alaska?	7.6.2
· What employment and income would be generated by the project?	7.6.2
· How many full-time jobs would be associated with the project?	7.6.2
· How would existing air services handle project additions?	7.7.2
· How would the project affect the Ports of Anchorage, Whittier, and Seward?	7.7.2
· How would personnel and supplies be moved during project operations?	7.7.2
· How would the project affect tanker traffic at the Port of Valdez?	7.7.2
· How would the project affect TAPS operations?	7.7.2
· How would an oil spill affect transportation?	7.7.2
· What would be the extent of visual impacts from the project to residents of Nuiqsut?	7.8.2
· Would air emissions from project construction or operation increase atmospheric haze?	7.8.2
· Would the flare be visible from the shore or from Cross Island?	7.8.2
· Would the light from the flare affect the bowhead migration pattern?	7.8.2
· Would an oil spill affect the visual/aesthetic characteristics of the project area?	7.8.2
· How would recreational activities be affected by the project?	7.9.2
· How would an oil spill affect recreational activities?	7.9.2

7.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge is included in this Environmental Impact Statement (EIS) in acknowledgment of the vast, valuable body of information about the Arctic that the Inupiat people have accumulated over many generations. This knowledge contributes, along with western science, to a more complete understanding of the Arctic ecosystem. Although Traditional Knowledge has been accumulating for a much longer time than western science, it has been maintained orally and recorded sporadically. While such transcriptions have occurred coincident to various research efforts, they rarely have been focused directly on the topics of this EIS. Therefore, in this effort to collect references to Traditional Knowledge on specific topics such as weather, marine conditions, and sea ice, the results are fragmentary and in no way represent the complete body of Traditional Knowledge on these topics.

Traditional Knowledge on the human environment was obtained from testimony by village elders, whaling captains, and other citizens from the villages of Barrow, Nuiqsut, and Kaktovik at the majority of hearings on North Slope oil and gas development held since 1979. Information also was obtained through personal interviews with concerned citizens in and around the project area. Reviews of engineering studies and environmental reports associated with previous and ongoing oil and gas exploration and development activities provided a source of additional Traditional Knowledge. Published and unpublished scientific reports and data; and environmental reports and studies conducted by universities, the oil industry, federal and state agencies, and the North Slope Borough (NSB) also were used as sources for Traditional Knowledge.

Inupiat names are spelled according to the transcripts of the hearings, and some statements have been paraphrased to make the information readily understandable.

7.2.1 Subsistence

Nearly all information on subsistence comes from Traditional Knowledge. For the purposes of this discussion, Traditional Knowledge that has been included addresses the overall importance of subsistence to the Inupiat culture and the relationships between the Inupiat, the land and water, and fish and wildlife resources. The importance of the bowhead whale to subsistence and the Inupiat culture is well known; additional knowledge on bowhead whales and subsistence can be found in Sections 6.2 and 9.2.

Testimony gathered from the Native communities describes the value and importance of subsistence in their lives and is summarized in the following text. Issues and concerns related to potential impacts to the subsistence lifestyle of the Inupiat are identified.

Subsistence filters into all aspects of Inupiat culture and provides the foundation for Traditional Knowledge passed down from generation to generation. From a western perspective, a subsistence lifestyle is dependent on natural resources and the availability of food and shelter. From a cultural perspective, it has spiritual meaning that is intertwined throughout daily life and extends throughout the community.

The importance of subsistence is described in a statement by Michael Pederson, a natural resources specialist for the Arctic Slope Native Association: *"The indigenous population in the coastal communities are dependent upon subsistence resources especially marine mammals such as bearded seals, walrus, polar bears, beluga whales, several species of fish, and the most important subsistence resource of all, the bowhead whale. Several land animals are also an important subsistence resource, such as caribou as well as migratory waterfowl. It is not only from the sea in which we gather our food, but on land where we hunt caribou, moose, wolves, wolverines, muskox, and foxes. Inupiat Eskimos do not only utilize these animals for food. We use other portions of the animals as well. Bearded seal skins are used to cover our traditional whaling boats, the umiaks. The sinew from caribou is used to stitch together the ugruk skins for our umiaks. Eskimo drums are made from the membranes of livers from bowhead whales, stomach linings from walrus, and skins from caribou. The skins from caribou are also used for making mukluks. Wolf and wolverine skins are used on our parkas. Local arts and crafts are also made from other parts of the animals not used for food.*" (Barrow Public Meeting) (USACE, 1996:46-47).

The bowhead whale is among the most important elements of the subsistence lifestyle of the North Slope Inupiat and integral to their culture. The marine environment is particularly important in supporting subsistence activities. Delbert Rexford testified at the scoping meeting in Barrow that: *"What I am most concerned about is that if and when there is development that occurs, that there is sound environmental impact statements prepared, and that the indigenous peoples, namely the people that depend on the subsistence resources, the whales, the walrus, the seals, the polar bear and other marine mammals, are* *consulted with. We speak of Kaktovik, Nuiqsut, and Barrow and other coastal communities that potentially will be impacted in the future. The sea is our garden, and our elders have always stated this."* (USACE, 1996:39). Edward S. Itta, a whaling captain and President of the Barrow Whaling Captains Association testified that, " *… the ocean is what holds our culture together..[and that means]...the [bowhead] whale."* (USACE, 1996:28). Bowhead whales are harvested by the communities of Barrow, Nuiqsut, and Kaktovik and annual hunting success can range significantly from community to community and from year to year (Section 7.3). Whaling success can be highly variable. A successful hunt distinguishes periods of ample food and raw materials from those years when resources are scarce and directly affects the spiritual well-being of whaling communities.

The importance of bowhead whale hunting to the subsistence lifestyle of the Inupiat is also illustrated in a statement made by Thomas Napageak, Mayor of Nuiqsut, at a public hearing in which he stated: "*The bowhead whale hunt plays an important role in the Inupiat community...Whaling remains a primary subsistence activity for Nuiqsut; however, whales are not merely subsistence issues. They are—they are the single most important animal in the North Slope socio-cultural system. Inupiat whaling is a proud tradition that involves ceremonies, dancing, singing, visiting, and cooperation between communities in sharing food. There's a—there is a high likelihood that the reduction or elimination of whaling could have severe ramifications of the socio-cultural and family network system of the Inupiat community.*" (USDOI, MMS, 1995:25).

Concerns raised during scoping on potential restrictions on access to subsistence resources and risks associated with increased travel to subsistence resources is based on more recent experience and Traditional Knowledge. Regarding potential impacts on access, Nelson Ahvakana stated: *"Like a good example is Prudhoe Bay. They say that area is open for subsistence, and it's not. It's written on paper that it is, but the actuality, you go and take a rifle over there, the first things - first thing that you are going to find out is that security's going to take care of you. They're not going to let you go anyplace, even though you say that I'm here on a subsistence hunt. They don't have any concern whatsoever about that; their concern is primarily the protection of that field, and this is exactly what is going to happen down there."* (USDOI, MMS, 1995:16).

During hearings on State Oil and Gas Lease Sale 85, Phillip Tikluk expressed concern that oil development would result in whalers having to travel further for whales and losing meat to spoilage: *"When you catch a whale, you have to cut it up before it gets bloated...the meat is no good when it gets bloated. But then (when) the oil developers start drilling around this place, then the whales and seals will be further out; (we will) have to go way out (in the ocean) in order to go hunting"* (ISER, 1983:8). In addition, whaling captains (Frank Long Jr., 1993:7 and 8) reported that whales become spooked and disturbed as a result of industrial activity and their abnormal behavior makes them more difficult to hunt.

7.2.2 Cultural/Archaeological Resources and Human History

The Inupiat have a unique culture and lifestyle they wish to retain. It is founded on traditions, practices, and beliefs passed down by generations. The importance of preserving their culture and lifestyle was illustrated by Michael Jeffrey during an offshore lease sale hearing: "*Significant stresses caused by the* *proposal on the Inupiat peoples' spirit, on their faith in traditional leadership, and on the organizations involved in their subsistence pursuits, may have a major impact on sociocultural systems. And I guess what that boils down to is a statement I would like to support, and that is, a major oil lease sale such as this would have additional major impacts on the life of the people here, from the point of view not only of their food and health but their spirit.*" (USDOI, MMS, 1983:73). During a public hearing for the Chukchi Sea Sale 109, Rex Okakok of Barrow stated: *"First, let me make a general statement regarding our aspirations as Inuit in the Arctic, A) we aspire to maintain our culture and be identified as distinct people, B) we continue to harvest wildlife as the basis of our culture, C) we aspire to conserve our wildlife harvest and ecosystem of which we have reliance, D) we aspire to develop socially, economically, in manners that are consistent with our aspirations, E) we aspire to look after ourselves and control our own lives."* (USDOI, MMS, 1987:33).

The importance of archaeological site preservation also has been expressed by North Slope residents. Michael Pederson stated that: *"It will be necessary to protect those archaeological sites that are known to exist on the coast near the Northstar Unit. Protection of these sites is necessary. We, the Eskimos on the North Slope are still learning about our past history, which is not in written form."* (USACE, 1996:55).

Potential restriction to access in the vicinity of oil field facilities can also affect use of cultural sites and Inupiat sense of place in relationship to the land. Alice Woods spoke on this subject: *"Like my mother was raised at Prudhoe Bay by Niakuk....That is the house my Grandpa built. We can't even camp there."* (USACE, 1996:58). Sarah Kanaknanah was raised in the area around Prudhoe Bay and the barrier islands; when she returned to Kanigliq in recent years: *" ... the pingoes used for duck blinds are now burning pits; the fishing and camping spot is now a barge landing dock. These places are threatened by development."* (USDOI, MMS, 1979). According to Besse Ericklook: *"The [barrier] islands have historic and cultural importance. Pingok Island has whalebones and old ruins."* (USDOI, MMS, 1979).

7.2.3 Land and Water Use

Traditional land use on the North Slope is based on subsistence activities directly linked to land and water use and the knowledge necessary to use the natural resources of the region. Hunting, fishing, and gathering berries and greens require knowledge of the environment and provide a spiritual connection with the land and sea.

The relationship between Traditional Knowledge and land and water use is illustrated by a statement made by Thomas Napageak when he was Mayor of Nuiqsut: *"I was born here in the Arctic Slope, and I have traveled and hunted throughout this region. Because of my lifelong experiences, I know about our environment and the wildlife population. I am fortunate to have learned from my ancestors their knowledge which they gained through years of living in our Arctic homeland…Above all, our priority is to protect our environment. The land from the Brooks Range to the edge of the shorefast sea ice is most sacred to the Inupiat. It provides us with nourishment for our bodies and culture…We here in Nuiqsut, by* *our own personal choice, left homes and jobs in Barrow to return to our ancestral lands to live in tents like our grandparents and to live off the land. We re-established an area which has always been used by our people. The land and coastal region provides us with our subsistence which is the foundation of our culture. We cannot live without our Native food, nor would we want to if we could…I have a responsibility to my land, my ancestors, and my children and their children to protect the environment which gave birth to the Inupiaq Culture.*" (USDOI, MMS, 1979:1-4).

Residents of Nuiqsut have historically used the area of oil field development east to the Sagavanirktok River, but have used it less due to a variety of reasons, including restrictions on access or physical changes to traditional use areas (Nelson Ahkvakana, in Section 7.2.1 and Sara Kanaknanah in Section 7.2.2). Thomas Napageak talked about traditional fishing areas: *"Oliktok, that's number one, that's where they used to fish during the month of August...All these points, all the way to Beechey Point. Those are the points they used to do a lot of fishing."* (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 14, 1996:16).

7.2.4 Socioeconomics

The subsistence lifestyle of the Inupiat and socioeconomic pressures from the west can be conflicting forces on the people of the North Slope. Traditional ways of life have changed for many residents and feelings among residents are mixed, yet, for some like Thomas Napageak who stated his preference for living in Nuiqsut, the subsistence lifestyle is preferable to the alternative. For others, the availability of jobs is paramount.

This conflicting socioeconomic view was expressed by Leonard Lampe of Nuiqsut during a public meeting for this project in Nuiqsut, who stated: "*...they need to think about their future as well in jobs and this might be the answer, but it might not be-- you know, it's a very hard decision to make. But I don't want to be the one to explain to their children or my children if there is no more culture, no more whaling. And we all know that the whaling is the base of our culture...*" (USACE, 1996:28).

Use of revenues generated from oil and gas development to compensate for subsistence and cultural impacts was discussed by several people in public meetings. Michael Pederson, a natural resources specialist for Arctic Slope Native Association, stated at a 1996 public meeting in Barrow: "*Impact funds should be made available to those communities located in the Beaufort Sea where oil and gas development is being proposed, and oil and gas lease sales will occur. Impact funds can be used to compensate communities for the possible loss of subsistence resources, as well as other potential impacts to the sociocultural and socioeconomic structures of these communities. Most communities on the North Slope survive on a mixed cash/subsistence-based economy. Subsistence is one way of putting food on the table for most residents where job opportunities are few. Impact funds should be made available as soon as possible.*" (USACE, 1996:58).

7.2.5 Transportation

Traditional Knowledge of the Inupiat includes travel to areas traditionally used for hunting, fishing, and gathering berries and greens. The subsistence lifestyle is dependent upon Traditional Knowledge, including knowledge of travel routes, terrain, and weather patterns. Hunting, fishing, and gathering requires knowledge of migratory and seasonal growing patterns and an awareness of environmental indicators that relate to these resources.

Testimony gathered for this project in 1996 from Nuiqsut residents expressed their desire for the oil industry to respect their right of access to culturally important resources, subsistence use areas, and traditional use areas. These areas also include historically and personally valued places, such as cemetery sites, Native Allotments, sacred sites, and home sites (Section 7.2.2).

7.2.6 Visual/Aesthetic Characteristics

Traditional Knowledge was given at public meetings for this project regarding visual and aesthetic characteristics and addressed incorporating project design with the environment and minimizing visual impacts on both wildlife and village residents. Concern regarding the visual and aesthetic characteristics has also been expressed at meetings for earlier development projects and in interviews with Inupiats regarding oil development.

At the scoping meeting in Nuiqsut, Leonard Lampe stated: *"I am concerned about a few things like if we are going to have flames out on the project....because it makes whales more spooked and more dangerous for the crews...I want to make sure if there are going to be any flames out there as well as discolorization to the environment, different colors. Also lighting, beams on the project as well. We are concerned...we would like you to try to make it [the project] as close as you can to the environment."* (USACE, 1996:24).

Ruth Nukapigak was one of the 128 people to re-settle in Nuiqsut in 1973. She had been born and raised in the area but had moved to Barrow. She longed to return to the place of her birth. In an interview on August 12, 1982, she stated: "*With all our might, we do not want [oil development] to have the land, especially the beautiful areas. Areas that should never be torn up. The areas that are most pleasing to my eyes, the most beautiful, are places [where the birds nested] in front of POW II, the islands. These are the ones that I do not want to be disturbed."* (Kruse et al., 1983:19).

7.2.7 Recreation

Traditional recreation activities of the Inupiat are interwoven into their subsistence lifestyle and culture and contribute to the social and emotional well-being of the community. Recreation cannot be described in "western" context because it is based on the subsistence lifestyle of the Inupiat. Many traditional games practiced during winter evolved through a need to maintain physical strength and agility required for hunting. Celebrations by the community typically result from hunting success, particularly bowhead whales.

7.2.8 References

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7.3 SUBSISTENCE

7.3.1 Affected Environment

The Inupiat Eskimo have inhabited the Arctic coast of Alaska for over 4,000 years and continue to practice a subsistence lifestyle of resource harvesting based on close interaction with the environment. Subsistence is central to the Inupiat culture. Many factors have converged over time which affect the success of resource harvesting. Harvesting practices are influenced by natural variability of resource populations, new hunting technology, economic forces, and governmental policy. Policy decisions by the state and federal government have resulted in restricted access to resources.

This section describes the subsistence lifestyle of Barrow, Nuiqsut, and Kaktovik residents. It addresses subsistence use of the bowhead whale and caribou, which are the primary subsistence resources likely to be affected by routine project construction, operations, maintenance, or abandonment. Although other resources, such as fish, seal, and waterfowl, are harvested by and important to the communities, biological data (Chapter 6) indicate that they are either not present in the area of consideration or would not be harvested from the area of consideration in large numbers. However, marine mammals (including bowhead whales), fish, and waterfowl could be affected in the event of an oil spill. Effects on subsistence from an oil spill are discussed in Chapter 8.

North Slope Inupiat culture, like other Alaska Native cultures, is characterized by the central importance of harvesting, processing, distributing, storing, and consuming wild foods (SRB&A and PJUCS, 1993:3-5), and the ability to utilize the resources around them for clothing, shelter, fuel, and ceremonial items. Within a culture based on the harvest of wild resources, the most significant beliefs and values revolve around three fundamental relationships: 1) the relationship between humans and the environment (including wild resources), 2) the relationship among human beings, and 3) the relationship between the people and their ancestry. The importance of the first two relationships stems from the fact that humans are dependent upon one another and their environment for survival. The third relationship demonstrates the knowledge and skills passed from generation to generation and the belief that those who came before knew the correct and proper way to live. The goal of subsistence is to maintain these relationships by harvesting in a manner respectful to the environment while accumulating resources that can be shared with other members of the community. Successful subsistence, then, is not only the harvesting of resources by an individual for their own use but includes the distribution of those resources through a network of social ties anchored by kinship.

7.3.1.1 Overview of Subsistence Harvesting

The populations of Barrow, Nuiqsut, and Kaktovik are predominantly Inupiat. In 1993, Barrow (the governmental hub of the NSB) had a population of 3,908, of which 61 percent (%) were Inupiat. The population of Nuiqsut in 1993 was 418, of which 91% were Inupiat. The Kaktovik population was 230, of which 84% were Inupiat. All three communities practice a subsistence lifestyle that is heavily dependent upon marine mammal hunting (especially bowhead whaling), caribou hunting, and fishing (Harcharek, 1994:BRW-1, KAK-1, NUI-1).

The Inupiat harvest a variety of resources depending upon the season and accessibility of resources; harvest patterns vary by individual communities (Figure 7.3-1). Some harvesters concentrate on one specific type of resource; others harvest a wide variety of resources throughout the year. Harvesters must be flexible and opportunistic, adapting to circumstances and available resources. Harvested resources are typically shared within families, within communities, and between communities.

A 1993 census of households found that 44% of Barrow households, 62% of Nuiqsut households, and 66% of Kaktovik households obtained half or more of their total meat consumption from resource harvesting (Harcharek, n.d.:BRW-34, KAK-32, NUI-32). Approximately 68% of Barrow households, and 90% and 89% of Nuiqsut and Kaktovik households, respectively, participated in subsistence activities. Participation in subsistence activities is identified by community and major subsistence resource category in Table 7.3-1. Of the 49 Nuiqsut households that reported a successful harvest from July 1, 1994, to June 30, 1995, 100% reported that they shared part of the harvest (Brower and Opie, 1997:9). Of the Nuiqsut total harvest instances reported for that study period, 87% resulted in sharing (Brower and Opie, 1997:9).

Communities on the North Slope maintain a mixed cash/subsistence economy that includes employment by government (federal, state, borough, and city), village and Native regional corporations, tribal councils, and private enterprise. Essentially, subsistence resources provide the staple of meat, fish, and fowl in the diet while income earned through employment is used to provide housing, heat and other basic living expenses, and to support subsistence activities (Kruse, 1991:317-326; Pedersen, 1995b:XXII-7).

For a detailed discussion of the cash economies of the NSB and its communities, see Section 7.6.1.

Barrow: Primary subsistence resources in Barrow have been the bowhead whale, bearded seal, caribou, fish, and migratory waterfowl, especially the king and common eider. Secondary resources have been the beluga whale, other seal species, walrus, polar bear, moose, furbearers, ptarmigan, and flora (NSB, 1979:14). In terms of useable pounds of subsistence resources harvested between 1987 and 1990, marine mammals contributed 55% of the useable subsistence resources. Terrestrial mammals contributed 30% of the subsistence resources, fish contributed 11%, and birds contributed 3.5% (SRB&A and ISER, 1993:63).

Nuiqsut: Primary subsistence resources in Nuiqsut have been bowhead whale, caribou, freshwater fish, and ocean fish. According to a recent harvest study in Nuiqsut, 49 (60%) of the 82 households surveyed reported that they harvested wildlife resources during the study period of July 1, 1994, to June 30, 1995 (Brower and Opie, 1997:8). Of the 71 Nuiqsut households interviewed, 76% reported that they attempted to harvest subsistence resources during the study period. During 1993, the community harvested approximately 76,400 pounds of whitefish, including broad whitefish, least cisco, and Arctic cisco, which totaled approximately 84% of their total fish harvest (Braund, 1997:84). Secondary resources have been beluga whale, seal species, moose, polar bear, furbearers, migratory waterfowl, ptarmigan, and flora (NSB, 1979:14). Nuiqsut subsistence harvests were studied for the 1992/1993 season, which was characterized by high rates of use and participation. Of all households surveyed, 100% used subsistence resources, while 94% attempted to harvest and 90% successfully harvested a subsistence resource. More than 77% of households that participated in the

Figure 7.3-1 (page 1 of 2)

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Table 7.3-1 (page 1 of 1)

study hunted for game and almost 81% fished (Pedersen, 1995b:XXII-12). Fish contributed 34% of the total pounds of harvested subsistence resources, marine and terrestrial mammals each contributed 33%, and birds and other resources constituted the remainder.

In the 1994/95 harvest period, terrestrial mammals (caribou and moose) accounted for 69% of the edible pounds of subsistence harvest by Nuiqsut hunters, fish accounted for 25%, birds for 4%, marine mammals for 2%, and plants for less than 1% (Brower and Opie, 1997:26). The considerably higher proportion of terrestrial mammals (69% in 1994/95 versus 32% in 1992/93), and the lower proportion of marine mammals (2% in 1994/95 versus 32% in 1992/1993) is likely the result of Nuiqsut hunters not landing any bowhead whales in 1994/95, whereas they harvested two bowheads in 1992 and three in 1993. Although Nuiqsut hunters generally harvest a variety of marine mammals, (e.g., bowhead and beluga whales, bearded seal, ringed seal, spotted seal, and polar bear), they only harvested ringed seal and polar bear in 1994/95 (Brower and Opie, 1997:28).

Although caribou accounted for 48% of the edible pounds of the 1994/95 Nuiqsut harvest, the 249-animal harvest was low compared to the 1985, 1992, and 1993 harvests (Brower and Opie, 1997:26). Nuiqsut hunters attributed this to the long distance they had to travel to harvest caribou, the effect of increasing musk ox that deter caribou away from hunting areas, and restrictions to traditional subsistence land use areas due to oil and gas exploration and development (i.e., areas used 10 years ago for hunting and fishing may have restricted access today due to being within development and exploration areas) (Brower and Opie, 1997:30).

The months of the highest caribou harvests were October and July in 1994/95, with the lowest harvests in May and June. This varies from the seasonal round presented on Figure 7.3-1, where April/May and August/ September were the primary months related to caribou abundance, hunter access, seasonal needs, and desirability. The months of the highest bird harvests in 1994/95 were April, May, and June, with no harvest during other months (Brower and Opie, 1997:12). In 1994/95, ringed seals were harvested in April, June, July, and August, which generally corresponds to the March/April and August/September time periods presented on Figure 7.3-1.

Kaktovik: Primary resources for Kaktovik residents have been bowhead whale, caribou, dall sheep, migratory waterfowl, and both freshwater and marine fish. Secondary resources have been beluga whales, seals, polar bears, moose, furbearers, ptarmigan, and flora (NSB, 1979:14). Fishing was the most common subsistence harvest activity with 81% of all households participating in fishing and 94% consuming fish. In terms of total pounds of subsistence resources harvested, composition of the overall harvest by major resource category shows marine mammals contributed the largest component (68%), followed by terrestrial mammals (17%), fish (13%), and birds and other resources (2%) (Pedersen, 1995a:XXI-6).

Bowhead Harvest Data: Recent harvest data (1964 to 1995) from Barrow, Nuiqsut, and Kaktovik whalers (Table 7.3-2) indicate bowhead harvesting success to be highly variable, ranging from no whales taken in

Table 7.3-2 (page 1 of 1)

Barrow in 1982 to as many as 23 at Barrow during 1976 and 1993. Nuiqsut harvest records began with the re-establishment of the community in 1973, and harvests have ranged from no whales to 4 per year; almost one-half of the annual hunts from 1973 through 1995 were unsuccessful in landing whales. Bowhead harvesting at Kaktovik also has been variable, ranging from no whales to 5 per year. In 1995, the whale strike quotas for Barrow, Nuiqsut, and Kaktovik were 22, 4, and 3 respectively. Recent Alaska Eskimo Whaling Commission (AEWC) data indicate that 45 whaling captains operate from Barrow, 10 operate from Nuiqsut, and 9 operate from Kaktovik, which may indicate that many whaling crews are unsuccessful. The relatively high number of landings reported from Barrow is likely to be a reflection of a two-season hunt and greater numbers of participants.

7.3.1.2 Factors Affecting Subsistence Activities

The success of subsistence harvesting is influenced by meteorology, ice and sea conditions, availability of game, species population cycles, industrial activities, and political and economic forces. Federal and state policy decisions have affected the way in which Alaska Natives pursue subsistence activities.

The Alaska Native Claims Settlement Act (ANCSA) (43 U.S.C. 1601, et seq.) in 1971, was passed with the intent to resolve aboriginal land claims and hunting and fishing rights of Alaska Natives in exchange for 44 million acres of land and $962.5 million (Freeman and Carbyn, 1988:56). ANCSA more clearly defined protection of subsistence resources and the responsibilities of both state and federal governments. Bowhead whales became protected under the Marine Mammal Protection Act of 1972 (16 U.S.C. 1388, et seq.) and the National Marine Fisheries Services became responsible for implementing and enforcing regulations regarding protection of the species. Local participation in management of bowhead whales was provided through a cooperative agreement between the National Marine Fisheries Services and the AEWC.

Passage of the Alaska National Interest Lands Conservation Act (16 U.S.C. 3101, et seq.) in 1980, was the first attempt at co-management of subsistence resources. This statute sought not only to protect natural resources and subsistence harvest opportunities on federal lands, but also sought to establish an administrative structure for management of public lands which would enable "rural residents who have personal knowledge of local conditions and requirements to have a meaningful role in the management of fish and wildlife and of subsistence uses on the public lands in Alaska" (ANILCA, Sec. 801(5)).

Bowhead Whales:

<u>Historical Factors</u>: Whaling was conducted by the Inupiat people using traditional methods until the mid-1800s, when American commercial whalers first arrived in the Alaskan Arctic. Traditionally, whaling was a community effort with many crews involved in the harvest, and the products distributed to the entire village. Only the number of whales which could be effectively harvested and consumed were taken. This form of cooperative hunting was efficient and reliable, produced a rich spiritual and ceremonial association with the bowhead, and acted as a conservation tool helping to ensure the stability of the bowhead population (Huntington, 1989:7-8).

This system was drastically changed in 1848 when commercial whalers began using weapons and techniques that made hunting more effective. Commercial whalers were concerned principally with harvesting the most whales, whose oil and baleen produced great profit. As a result, whale stocks were decimated. Commercial whalers began taking walrus when the whales became scarce and the walrus population was reduced so drastically that villages dependent upon walrus for meat starved during the winter (Huntington, 1989:9). Subsistence whaling efforts returned to low levels at the end of the commercial whaling era in the 1920s due to declines in bowhead numbers and the Eskimo population.

By the 1970s Alaskan Eskimo whale harvests had begun to increase from average annual catches of approximately 12 from 1910 though 1969 to 32 between 1970 and 1977 and there was concern that the species would become over-harvested (Huntington, 1989:13). Based on the level of subsistence whaling activity and erroneous estimates which numbered the bowhead whale population between 800 and 2,000 animals, the International Whaling Commission (IWC) voted in 1977 to ban aboriginal hunting rights to the bowhead whale.

In response, Eskimo subsistence whalers established the AEWC to fight the ban, organize the whaling communities, and manage the hunt themselves. A special meeting of the IWC in December 1977, resulted in a 1978 quota of 18 whales struck or 12 whales landed, which was later amended to 20 struck or 14 landed to accommodate fall harvesting. Certain that IWC population estimates were too low, the AEWC called for additional scientific studies. A cooperative management agreement was signed between AEWC and the National Oceanic and Atmospheric Administration in 1981, which places enforcement responsibility of IWC-set quotas with the AEWC (Huntington, 1989:35). Table 7.3-3 lists the IWC quota and harvest data from 1978 to 1991 for the ten villages that engage in subsistence whaling in Alaska. Based on an improved methodology, as suggested by subsistence whalers, bowhead whale population estimates have increased steadily since 1978. Shore-based visual surveys conducted at Point Barrow from 1978 through 1983 yielded a population estimate for that period of about 3,500 to 5,300 animals (Zeh et al., 1993:479). Revised estimates of population size, based on visual and acoustic data collected during the 1993 census off Point Barrow, indicate that the most probable size of the 1993 population was 8,200, with a 95% probability that the population was between 7,200 and 9,400 (Zeh, et al., 1996:1). This estimate was recognized by the IWC and is more in line with recent reports from local Inupiat people.

Prior to implementation of the first IWC quota for the 1978 bowhead whaling season in Alaska, Alaska Eskimos had no external control on the number of bowhead whales they could harvest. If whales were struck and lost, hunters continued hunting until they harvested what they needed for their families and community. With the implementation of the IWC quota, the categories of landed whales and struck and lost whales became monitored, and are assumed to be eliminated from the whale population.

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The AEWC monitors the annual efficiency rate (the percentage of whales landed in a year from the total quota for that year) and reports it to the U.S. Government and the IWC. Whales that are struck and lost lower the efficiency rate for that year. When the IWC periodically reviews the Alaska bowhead subsistence quota, it considers the efficiency rate in determining the quota for future years. Declining or low efficiency rates are not viewed favorably by the IWC and tend to have a negative effect on the quota determination for upcoming years. Any activity or practice that results in a lower efficiency rate tends to work toward a lower quota in the future. The AEWC and the Alaska bowhead whalers work diligently toward increasing their efficiency rate.

Environmental Factors: The bowhead whale migration is affected by meteorology, ice and sea conditions, and availability of food. The Beaufort Sea spring migration is in an easterly direction during late-April to early-June; whereas fall migration to the west extends from late-August to early-October (Figure 6.9-1). The fall migration is more leisurely with some localities being used as staging areas due to abundant food resources (W. Bodfish in NSB, 1981:296). Prevailing winds affect leads by holding them open or affecting the density of the sea ice. Whales tend to migrate closer to shore in light ice years compared to years with dense ice (George et al., 1995:378). Clear leads allow better access to migrating whales and probably more efficient recovery of struck whales (George et al., 1995:379). During years when fall storms push ice against the barrier islands in the Alaskan Beaufort Sea, whales have been known to migrate south of Cross Island, Reindeer Island, and Argo Island where the swimming is easier (T. Brower Sr. in NSB, 1980:107).

This natural variability can affect where whales are encountered and harvested on a year to year basis. When whalers must travel farther to harvest whales, costs associated with the hunt, danger of being caught in bad weather, and the risk of meat spoilage all increase.

Bowhead whales have been hunted for at least two millennia at the same sites and with the same basic hunting methods, which suggests that the effects of harvesting have not caused the basic migratory behavior to change over time (George et al., 1996:1). However, noise is known to affect migratory patterns and behavior. Studies of bowhead whales indicate that industrial noise may cause behavioral changes at distances of as much as 6.2 miles (10 kilometers [km]), and deflection behavior at ranges of 0.5 to 14 miles (1 to 23 km), although most deflections occurred at less than 6.2 miles (10 km) (George et al., 1996:5). Other studies have found avoidance behavior at a range of 1 to 9 miles (1.6 to 14.5 km) from small boats and vessels (Richardson et al., 1995a:268; Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61; LGL and Greenridge, 1987:47; and Ljungblad et al., 1985:45). This is consistent with observations by whaling captains that scatter behavior from an outboard motor occurs within 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107). Davis et al. (1985:64) observed an unknown number of whales present around a gravel island used for drilling at a distance between 1.6 and 3.8 miles (2.6 to 6 km); however, other factors regarding this observation are unclear.

Whaling captains (Frank Long Jr., 1993:7 and 8) reported that whales become spooked and disturbed as a result of industrial activity and, hence, are more difficult to hunt due to their abnormal behavior. Local testimony indicates that it takes at least two weeks before the normal bowhead whale migration route is re-established after a disturbance (B. Rexford in USACE, 1996:62). Whalers have also noted that when industrial activity in the Alaskan Beaufort Sea is high, harvest success is low and quotas are not easily met (J. Ningeok in USDOI, MMS, 1986:16; F. Long, Jr. in USACE, 1996:34; B. Oyagak in USDOI, MMS, 1986:11; J. Kaleak in MBC, 1996:69; T. Napageak in USDOI, MMS, 1995a:8).

Seismic exploration activity is of particular concern, and whaling crews have observed migration diversions of up to 40 miles (64 km) as a result of seismic noise (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:16). Monitoring results during a fall 1996 seismic survey within and around the Northstar Unit found that the migration band tended to narrow and shift approximately 6.2 miles (10 km) further offshore during operations (Richardson, 1997:5-52).

Caribou: Caribou winter in the foothills of the Brooks Mountain Range and move to the calving grounds on the open tundra in late April to early June. Bulls, yearlings, and non-pregnant cows join the cows and newborn calves in mid to late June. Calving occurs particularly in the Kuparuk River delta calving area and the Canning River Delta (Figure 6.8-1) with the majority of calving occurring within 24 miles (39 km) of the coast. Calving does not typically occur within the developed oil fields between Kuparuk and Sagavanirktok Rivers (Whitten and Cameron, 1985:10). The Kuparuk calving area location has shifted slightly to the west-southwest in 1987 through 1990 in response to construction of the Milne Point Road.

Early summer marks the arrival of insect season for the caribou, causing migration from the inland to the coast (Pollard and Noel, 1994:44). As insect harassment abates, the caribou return to inland feeding grounds.

The Central Arctic Herd has been extensively studied since the early 1970s due to concerns that oil field development has caused displacement. Hunters in Kaktovik have testified frequently that caribou are less abundant (N. Solomon in USDOI, MMS, 1979:16; J. Ningeok in USDOI, MMS, 1982:28; I. Akootchook in USDOI, MMS, 1990:10). Changes in caribou population during the 1970s and 1980s indicate that such fluctuations are part of herd population dynamics and may not be attributable to human intervention.

The population of the Central Arctic Herd currently is beginning to decline following an increase of 15% from 1978 to 1983 and a 5% increase from 1983 to 1994. The decline rate from 1994 to 1995 was 5% (Cameron et al., 1994:3).

7.3.1.3 Access to Subsistence Harvest Areas

Harvest Area: Subsistence harvest areas used by residents of Barrow, Nuiqsut, and Kaktovik include a large part of the project area (Figure 7.3-2). The Colville River, its tributaries, and Harrison Bay are hunted by Barrow and Nuiqsut residents; the area from the Colville River to Prudhoe Bay is hunted by residents from Nuiqsut and Kaktovik and both Nuiqsut and Kaktovik residents use areas east of Prudhoe Bay. Areas used by all three communities extend inland to the Brooks Range.

Use areas for bowhead whales and caribou (Figures 7.3-3 and 7.3-4, respectively) are expansive, since different villages or sites would be used at different times of the year in response to different subsistence resource availability. It was typical for people to move from one living site to another during the year and to settle in different villages over the course of their lives (IAI, 1990a:1-4). With the formation of permanent villages, the arrival of modern technology, motorized access to outlying resource areas, and the development of mixed wages/subsistence economies, residents continue to use broad harvest areas, although the time spent in these areas may be reduced.

With modern technology, hunters are able to travel to historic harvest areas in less time; technology has not led to a reduction in area used, it has made it more efficient to travel to key areas. Furthermore, technology has enabled North Slope residents to travel to distant traditional use areas for seasonal occupation while maintaining permanent residence in their community. Comparing the 1987-90 Barrow subsistence sites (SRB&A and ISER, 1993:43) and the Barrow key informant hunting areas from 1990 (Braund, 1997) with Barrow lifetime community harvest areas (Pedersen, 1979:10), indicates that Barrow hunters in the late 1980s continued to use the broad areas. Furthermore, modern technology (powerful outboard motors and aluminum boats) has substantially increased the Barrow fall bowhead whaling hunting area in recent decades (ACI et al., 1984:200) and modern whalers travel as much as 30 miles (48.2 km) or more offshore.

In some cases, there has been a reduction in accessible hunting areas by the construction and gradual expansion of the oil development "footprint" at Prudhoe Bay (J. Nukapigak and H. Rexford - pp. 9 and 21, respectively, in Kruse et al., 1983). In other cases, hunters claim they have to go further, or it is harder to harvest bowhead whales in the fall, due to seismic activities and oil development (P. Tikluk in ISER, 1983:8; F. Long, Jr. in USACE, 1996:34; D. Rexford in USACE, 1996:40-41).

Barrow Harvest Areas: Barrow hunters use an area from Wainwright to the southwest and to the Colville River Delta to the southeast. The majority of coastal travel is from Peard Bay to Admiralty Bay. Coastal areas are extensively used throughout summer and fall, and to a lesser extent in winter and spring. During 1990, Barrow residents utilized 80 to 90 inland cabins for subsistence hunting and fishing. Spring whaling is conducted from temporary campsites established on the seaward edge of the shorefast ice.

Nuiqsut Harvest Areas: Nuiqsut hunters use areas which range from Cape Halkett (at the northwest end of Harrison Bay) to Flaxman Island, extend south to the Brooks Range, and north approximately 30 miles (48 km) offshore (IAI, 1990b:1-5). Prime caribou harvest areas are essentially the same for both summer and winter harvests: along the coast from Cape Halkett in the west to Oliktok Point in the east (IAI, 1990b:1-16) (Figure 7.3-5). During the winter, the eastern limit is typically the boundary of the Kuparuk oil field.

Cross Island is an offshore site of particular importance, as it is used as the base camp for fall whaling by Nuiqsut hunters. Although Nuiqsut's first two landed whales (1973 and 1982) were struck near Flaxman Island, between the early 1980s and 1998, all reported whale sightings and strikes are bounded by a core whaling area around Cross Island from the Midway Islands to Bullen Point (IAI, 1990b:1-28) (Figure 7.3-6). Due to logistical considerations and migration patterns, it would be unusual to strike a whale outside of this area as the tow to the base camp would simply be too long.

Kaktovik Harvest Areas: Kaktovik residents use an area from Tigvariak Island to the Canadian border, inland to the Brooks Range, and approximately 20 miles (32 km) offshore (IAI, 1990a:1-30). Most caribou harvesting is in an area between the Canning River and Griffin Point/Pokok Lagoon (IAI, 1990a:1-13). Summer and winter use areas in 1990 are shown on Figure 7.3-7.

Fall whaling takes place using the village as a daily home base. The core area for Kaktovik bowhead whaling extends from the Okpilak and Hulahula Rivers in the west to Tapkaurak Point in the east, and 20 miles (32 km) out to sea (Figure 7.3-8). Nearly all whales caught since 1964 have been from this core area (IAI, 1990a:1-20 through 1-21). The extreme limits of the middle of Camden Bay in the west and the mouth of the Kogotpak River in the east are the logistical limits of towing a whale to Kaktovik before spoilage.

7.3.2 Environmental Consequences

Environmental impacts to subsistence harvesting have been evaluated for those resource species that would be affected by construction, operation, maintenance, or abandonment of each project alternative. This analysis applies information about species population dynamics, migration patterns, species reaction to impact events (i.e. noise), harvest information, harvesting areas, harvesting methods, access to harvesting areas, and project-related actions that would represent a potential impact to resources. Subsistence species that are most likely to be affected by project construction, operations, maintenance, or abandonment are limited to the bowhead whale and caribou. Impacts from Alternatives 2, 3, 4, and 5 are presented and summarized in Table 7.3-4.

Figure 7.3-2 (page 1 of 2)

Figure 7.3-2 (page 2 of 2)

Figure 7.3-3 (page 1 of 2)

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Figure 7.3-4 (page 1 of 2)

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Figure 7.3-5 (page 1 of 2)

Figure 7.3-5 (page 2 of 2)

Figure 7.3-6 (page 1 of 2)

Figure 7.3-6 (page 2 of 2)

Figure 7.3-7 (page 1 of 2)

Figure 7.3-7 (page 2 of 2)

Figure 7.3-8 (page 1 of 2)

Figure 7.3-8 (page 2 of 2)

Table 7.3-4 (page 1 of 3)

Table 7.3-4 (page 2 of 3)

Table 7.3-4 (page 3 of 3)

7.3.2.1 Alternative 1 - No Action Alternative

Subsistence harvesting is expected to continue to be important to the lifestyle of Barrow, Nuiqsut, and Kaktovik residents, regardless of the alternative selected. Bowhead whaling and its cultural importance, the harvesting of other important subsistence species, and the use of subsistence products have evolved through thousands of years and will continue. Harvesting techniques are likely to continue to evolve, utilizing new equipment, technology, and methods to improve hunting and travel efficiency as they become available. Acquisition of new types of equipment would continue to be possible through continuation of the mixed wage/subsistence economy and the availability of sufficient personal income for such expenditures.

Oil field development within the North Slope is likely to continue, regardless of development of the Northstar Unit. Bowhead whale harvests in Nuiqsut and Kaktovik have been variable and in many years "unsuccessful." Such variability in harvest success is likely to continue regardless of project development. Therefore, impacts related to subsistence harvesting as a result of the No Action Alternative are not anticipated.

7.3.2.2 Alternatives 2, 3, 4, and 5

Impacts to subsistence resources and the subsistence lifestyle resulting from project construction, operation, maintenance, and abandonment under Alternatives 2, 3, 4, and 5, are discussed below. Alternatives 2, 3, 4, and 5 all use Seal Island and differ in onshore and offshore pipeline locations and lengths. Impacts to subsistence harvest resources (bowhead whale and caribou) within the project area would not differ among alternatives.

Construction Impacts: Subsistence resources most likely to be affected by construction activities are the bowhead whale and caribou. Although local residents harvest several species of marine mammals, terrestrial mammals, fish, and birds, harvesting has not been permitted within the Prudhoe Bay industrial complex since the 1970s. Available data indicate that harvest activities in the offshore portion of the project area are associated with travel through the area. A review of harvest areas used by residents of Barrow, Nuiqsut, and Kaktovik indicates that current subsistence activities are more focused in an area closer to existing communities, compared to the larger historic use area boundaries. However, more distant areas have been traditionally used and may be used in the future, depending on the distribution of fish and wildlife resources.

Among the three Alaskan Beaufort Sea communities, spring harvesting of bowhead whales during this west to east migration is only practiced by Barrow residents, and occurs approximately 150 miles (241 km) to the west of the project area. Construction activities that occur in the spring are not expected to impact the migration patterns or subsistence harvest success of the bowhead whale during the Barrow spring hunt. There is a chance that the noise associated with fall construction activities could impact the fall whale subsistence harvest of Nuiqsut residents who utilize Cross Island as a base camp. However, fall construction activities are intentionally scheduled so as to not include activities that produce relatively high levels of underwater noise. Kaktovik is located to the east of the project area, and no impacts to the

Kaktovik fall bowhead harvests are expected.

Fall whale sightings in the vicinity of the project area from 1980 through 1995 are depicted on Figure 6.9-2. Miller et al. found mean migration pattern distances from Seal Island to range from 13 to 22 miles (21 to 35 km) during light ice years and 32 to 40 miles (52 to 64 km) during heavy ice years (Miller et al., 1996:35); however, whales have been seen migrating south of Cross, Reindeer, and Argo Islands when fall storms push ice against the barrier islands in the Alaskan Beaufort Sea (T. Brower in NSB, 1980:107). The core harvest area from mid-1980s to 1990 for Nuiqsut whalers encompasses an area approximately 10 miles (16 km) to the west of Cross Island, 40 miles (64.4 km) to the east, and 30 miles (48.3 km) north (Figure 7.3-6). Seal Island is approximately 17 miles (27.4 km) to the west of Cross Island.

While the majority of construction activities are scheduled to be completed in the spring and summer months prior to the bowhead western migration, some activities could continue into the fall months when the migration is taking place. Construction activities that would take place during the fall and potentially coincide with the fall bowhead migration (late August to early October) of the first year include grading gravel on Seal Island, the installation of filter fabric and slope protection, preparation for and off loading of modules, module installation and hook-up, and drilling rig mobilization. The resupply of drilling consumables by boat and helicopter would take place during the fall of the second year and drilling and well completion would be ongoing during three fall seasons.

Although noise generated from such activities would be variable and dependent upon the types of vessels and equipment used, ocean-going tugs are likely to elicit the greatest reaction from migrating bowheads. Tugs can emit high levels of underwater noise at low frequencies. Tugs are one of the loudest types of vessels, so their sounds could travel farther than other vessels. In August 1985, underwater noise was recorded from two tugs that were keeping a barge pressed against a loading ramp at Sandpiper Island. An underwater sound level of 163 decibels (dB) in the 20 to 1,000 hertz band was recorded at a distance of 0.3 miles (0.5 km) (Miles et al., 1987:106). Peak noise levels (118 dB) in the 20 to 1,000 hertz band were noted at a range of 1 mile (1.6 km) when tugs and barges were present at Seal Island (Davis et al., 1985:61).

Avoidance reactions of bowhead whales to small boats have been observed at distances up to 2.5 miles (4 km), but most reactions have been observed at ranges of less than 1.2 miles (1.9 km), often when measured levels of underwater noise were less than 90 dB in the 1/3-octave band of maximum noise (Richardson et al., 1985a). The negative response is probably learned by association at these ranges and sound levels, and the animals probably represent the more sensitive segment of the population. The most overt responses are those for whales observed within 0.6 miles (1 km) of an approaching vessel. Whales usually avoid the approaching vessel by trying to outswim it, and response is probably mediated more by the rate of increase in the noise, level than by the absolute received level. If overtaken, the whale will turn to swim away from the path of the vessel. These animals probably represent the segment of the population that is less sensitive to vessel noise, since they are the animals seen closest to vessels. Whales tend to show little response to vessels that move slowly and are not heading toward them (Richardson et al., 1995a:268-270).

Small vessels are, however, more likely to be present than tugs and larger vessels. Observations from whalers and data from studies indicate that deflection from small vessels is likely to occur between 1.2 to 6 miles (2 to 9.7 km) (T. Brower, Sr. in NSB, 1980:107; Ljungbald et al., 1985:45; Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61), which would be outside the Cross Island harvest area. Whales near the western boundary of the Nuiqsut harvest area are not expected to be affected by small vessels operating at Seal Island. Therefore, there is little likelihood that some whales in this area would be unavailable to hunters, but the overall effect of small vessel operations on the harvest is expected to be minor.

Inupiat hunters have also reported that bowheads are frightened by vessel noise and that bowheads would avoid approaching vessels that are attending a drilling vessel. The direct relationship of avoidance is further demonstrated by observations that whales are not present when vessels are present, but return in the absence of vessel operations. The avoidance response is such that whales have been observed to travel as far as possible from ship activity (A. Brower in USDOI, MMS, 1986:52; J. Ningeok in USDOI, MMS, 1986:16).

Bowheads respond to boats by spending less time at the surface, taking fewer breaths when surfacing, and changing swimming speed and direction. These types of reactions were evident at distances of at least 2.5 miles (4 km) from the vessel (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). The underwater noise levels to which the reacting animals were exposed were often not any higher than noise levels experienced during Sea States 1-2 and, in one case, a mother and calf reacted when the nearest approaching vessel was approximately 9.3 miles (15 km) away (Richardson et al., 1985a:116; Koski and Johnson, 1987:59).

If large ships are active near Seal Island during fall bowhead whale migration, deflection behavior could occur at the western border of Nuiqsut's bowhead harvest area. If the whales are deflected at a distance of 25 miles (40 km), and if no whales were struck within the eastern range of the Cross Island whaling area, impacts to the fall whale harvest could be significant. Although highly unlikely because of the planned schedule of island construction activities, there is a slight chance that some bowheads which are close enough to hear large vessel noises might move offshore from their normal migration path. If this happened, there is a remote possibility that a few whales near the western boundary of the Cross Island whaling area might deflect offshore, making them unavailable to the hunters, thereby limiting whaling success.

To the extent that industrial activities interfere with the subsistence bowhead hunt and cause a lost whale, that whale is deducted from the year's quota and results in a lowered efficiency rate. If this occurs, the industrial activity has negatively affected the bowhead hunt in two ways. First, the meat from that whale is lost permanently, and second, the resultant lower efficiency rate has a negative impact on future whale quota allocations by the IWC. If a crew is unable to complete the take of a skittish or spooked whale (e.g., they have struck it, but due to the whale's abnormal behavior they cannot kill or land it), that whale counts as a struck and lost whale (lowering the efficiency rate).

If whales are displaced further offshore as a result of industrial activities, this not only increases the risk and danger to hunters who travel far offshore in pursuit of bowheads, it also increases the likelihood that the meat will spoil during a long tow. A whale whose meat spoils during a long tow counts as a landed whale, and does not reduce the efficiency rate. However, the meat is lost due to spoilage, and since that whale counted against the IWC quota, it cannot be replaced. The lost meat is a permanent loss. Furthermore, if a whale is struck and killed far from shore and has to be cut loose due to ice and/or weather, it also counts against the quota, the meat is permanently lost, and the efficiency rate is lowered (as it counts as a struck-but-lost whale). In the context of the IWC quota, any disturbances to bowheads by either displacement or spooked or skittish whales has added impacts to Alaska Eskimo whalers.

Anadromous/amphidromous fish (broad whitefish, least cisco, and Arctic cisco) which migrate through the project area (Figures 6.4-1 and 6.4-2), are important to Nuiqsut subsistence harvests. Impacts to the species are expected to be negligible (Section 6.4) and annual migration to the Colville River is expected to remain unchanged and result in no impact to fish harvest success in the area.

The project area is not used by subsistence hunters in the spring and rarely in the summer, when the majority of open water construction activities will be performed. Transportation routes used for subsistence harvesting are not expected to be affected by project construction because boat traffic in the area would not be curtailed.

Onshore pipeline construction would take place during winter through early summer, possibly displacing some caribou. Onshore pipelines would be elevated on vertical support members with a minimum clearance of 5 feet (ft) (1.5 meters [m]), a height that would allow caribou free passage under the pipelines (Cronin et al., 1994:7). Because earthen ramps would be constructed over the pipeline in other locations to allow crossing, and pipeline corridors are not near calving areas, no impacts to caribou migration patterns are expected. Helicopter traffic between Seal Island and Deadhorse Airport, Prudhoe Bay airstrip, and Kuparuk airstrip would not cross caribou calving areas, although some areas used for rearing calves could be crossed. Low-level helicopter traffic would cause a short-term disturbance to caribou during insect season as the animals move to the coast. No impacts to caribou harvests are anticipated.

Operation Impacts: During project operation, noise would be generated by drilling activities and boat and helicopter traffic to and from Seal Island. Drilling noise is expected to have less effect on bowhead whale migration than that of construction noise, because drilling through the island would attenuate noise levels (Chapter 9). Measured noise levels during island drilling operations and measured ambient noise levels for the Seal Island site suggest that, under quiet noise conditions, bowheads could hear drilling noises at distances of not more than 6.8 miles (11 km) (Johnson et al., 1986:86; Malme and Mlawski, 1979:1; Richardson et al., 1985a:127-129). The worst case impact would be that the bowhead whales which swim near Seal Island would tend to avoid swimming within 6 miles (10 km) of the site. The reaction of bowhead whales to vessel noise is documented through observations from Inupiat hunters and from marine mammal surveys. Although the avoidance reaction due to noise from a small boat has been noted at distances as short as 1.2 to 2.5 miles (1.9 to 4.0 km) (Richardson et al., 1995a:268), observations related to outboard motor operations noted avoidance reactions at approximately 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107). Reactions to moderate-sized vessels have ranged from 6 miles (9.7 km)

(Ljungblad et al., 1985:45) to 9.3 miles (15 km) (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61).

Observations and studies of bowhead behavior associated with other large noise sources showed avoidance of noise from a drilling vessel at distances of approximately 13 to 15 miles (21 to 24 km) (LGL and Greenridge, 1987:41), which has been found to affect subsistence harvesting (T. Napageak in USDOI, MMS, 1995a:13; B. Adams in USDOI, MMS, 1995b:26; H. Brower, Jr. in USDOI, MMS, 1995b:84; B. Rexford in MBC, 1996:80; J. Kaleak in MBC, 1996:69; B. Oyagak in USDOI, MMS, 1986:11) and cause migratory path displacement during drilling activities.

The 1985 harvest failure at Kaktovik has been directly attributed to exploratory drilling operations (J. Kaleak in MBC, 1996:69). Two drilling activities during open water that year were the Hammerhead prospect, 34 miles (55 km) east of Cross Island, drilled by ship between August 10, 1985 and September 24, 1985; and the Harvard prospect, spudded from a gravel island within the Sandpiper unit in September. The location of the drilling vessel may have caused disturbance within the path of the fall migration pattern, near the Kaktovik subsistence harvest area. Nuiqsut whalers also experienced poor harvesting success during the 1985 season (B. Oyagak in USDOI, MMS, 1986:11) (Table 7.3-2). During the last several years, seismic and other oil exploration activities have been coordinated with the AEWC to minimize adverse effects on subsistence whaling, and have been subject to stipulations in agreements with the AEWC. Additional information regarding bowheads' reaction to industrial noise is provided in Chapter 9.

The displacement of the bowhead migratory path and their avoidance of the Prudhoe Bay industrial area has been observed (J. Tukle in USDOI, MMS, 1987:47; P. Tukle in USDOI, MMS, 1986:23). Displacement from migratory paths in other areas of the Alaskan Beaufort Sea has required additional travel by subsistence hunters, which can lead to meat spoilage due to extended haul distances and times (D. Rexford in USACE, 1996:41), increased risk to the hunters, and increased fuel requirements, which would lead to significant impacts to subsistence harvesting of Nuiqsut.

Information about visual impacts from colors, flares, and facility lighting is limited to Traditional Knowledge that indicates that bright colors can cause avoidance behavior in bowhead whales (Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996). Facilities on Seal Island will be painted in unobtrusive colors and flare operations would not exceed 30 days per year. When operating, the flare would be smokeless, virtually transparent, and light yellow and blue. Other features that have been incorporated into the facility design include minimal usage of outside lighting and the use of directed lighting to reduce light scatter and glare. Although the distance at which the flare and/or lights would affect the bowhead is unknown, some adverse impacts are expected. If sufficiently severe, impacts to subsistence harvesting could be significant.

A large oil spill could affect subsistence harvesting. Although impacts would vary greatly depending upon quantity, location, and meteorological conditions during the time of a spill, impacts to subsistence harvesting are likely to result through the direct loss of resources, displacement of resources, and/or contamination. A discussion of effects of oil spills on subsistence is presented in Chapter 8.

Routine operation would generate some helicopter traffic associated with crew and material transfer between the Seal Island and the mainland, and routine inspection overflights of the pipeline. However, as mentioned under construction, helicopter traffic from Deadhorse to Seal Island would not cross any caribou calving areas. Some short-term disturbance could occur when caribou are present along the coast for relief from insects. However, subsistence harvest of caribou is not likely to be affected by operation activities.

Maintenance Impacts: If maintenance activities at Seal Island were to take place during the bowhead fall migration period, noise from gravel backpassing, slope protection repair, and similar activities could generate a variety of noise patterns that would have a greater impact on the bowhead migration pattern than that of routine operational noise. Under such circumstances, this noise may further contribute to significant impacts to the subsistence harvest if a deflection in bowhead whale migration patterns were to occur.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan adopted at the end of the useful life of the project. Abandonment impacts will be addressed in the assessment of the environmental effects of the abandonment alternatives presented in that plan. If an abandonment scenario called for complete removal of all facilities and infrastructure during the bowhead whale fall migration, impacts to the Nuiqsut subsistence whale harvest could be significant. The level of impact would depend on the type of noise generated by abandonment activities and the degree of avoidance behavior of the whales. A scenario involving in-place abandonment and/or reuse of a substantial portion of the project facilities could benefit hunters because Seal Island could be used during unexpected adverse weather while traveling between Nuiqsut and Cross Island.

7.3.3 Summary of Environmental Consequences

Although several design components have been incorporated into the project to lessen the severity of impacts, noise from vessels in the vicinity of Seal Island during the fall migration and from island reconstruction and slope maintenance are expected to cause the greatest impact. The possible impacts could include reduced harvest success and increased time and travel distances which would add risk to whalers, increase the risk of meat spoilage, and increase fuel requirements. Should increase risks to whales be perceived by the IWC, the subsistence harvest quota could be reduced.

A pattern of unsuccessful annual harvests caused by construction, operation, or maintenance noise would be an irretrievable and irreversible loss of the bowhead subsistence resource and could cause declines in the sharing of Traditional Knowledge, sharing of culturally important foods, and cultural events associated with the harvest of bowhead whales. A single unsuccessful harvest season attributed to the project would be a short-term irretrievable and irreversible loss of the bowhead whale resource and temporary declines in important cultural activities. Short-term impacts would be greatest during the construction phase of the project, but disturbing noise from operations and maintenance during the fall migration could affect the productivity of the Nuiqsut whale harvest if noise-intensive activities were to occur near Seal Island during the fall harvest period.

Studies conducted after the Exxon Valdez oil spill suggest that a disruption of a complex cultural system disrupts essential systems of meaning and social integration within Native communities. A native informant in one spill-affected community observed: "When we worry about losing our subsistence way of life, we worry about losing our identity….It's the spirit that makes you who you are, makes you think the way you do and act the way you do and how you perceive the world and relate to the land. Ninety-five percent of our cultural tradition now is subsistence…its what we have left of our tradition." (Russell et al., 1996:875).

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised. For a discussion of Environmental Justice considerations, see Section 7.10.

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7.4 CULTURAL/ARCHAEOLOGICAL RESOURCES AND HUMAN HISTORY

7.4.1 Relevant Legislation Affecting Cultural Resources

NEPA was passed in 1969 with the intent to “declare a national policy which will encourage productive and enjoyable harmony between man and his environment...” (42 U.S.C. 4321). The Act stipulated that one way the Federal Government would carry out this policy is by “preserv[ing] important historic, cultural, and natural aspects of our cultural heritage...” (42 U.S.C. 4331(b)(4)). The laws which present the federal policy regarding historic preservation include the National Historic Preservation Act (NHPA) of 1966, as amended (16 U.S.C. 470 et seq.); the Antiquities Act of 1906 (16 U.S.C. 431 et seq.), which protects archaeological remains and items of antiquity; the Archaeological Resources Protection Act of 1979 (16 U.S.C. 470 et seq.); the Abandoned Shipwreck Act of 1987 (P.L. 100-298); and the Native American Graves Protection and Repatriation Act (25 U.S.C. 3001-3013). State and local governments also may dictate policy regarding historical and cultural resources, such as the Alaska Historic Preservation Act (AK 41.35.240). NEPA works in conjunction with these laws to ensure the preservation of cultural resources.

The NHPA established the National Register of Historic Places, a listing of significant archaeological sites and historic properties. Historic property is defined in the Code of Federal Regulations (at 36 CFR 800.2[e]) as “any prehistoric, or historic district, site building, structures, or object included, or eligible for inclusion in, the National Register.” Section 106 of the NHPA established protocols for federal agencies to use in evaluating the effects of their actions on historic properties. These protocols are found in 36 CFR 800.1-800.15.

The NHPA dictates that a State Historic Preservation Officer (SHPO) (16 U.S.C. 470[b][1][A]) work in conjunction with each state to preserve and protect historic properties. The State of Alaska has an inventory of known historic and prehistoric sites, the Alaska Heritage Resources Survey, which is maintained by the Alaska Department of Natural Resources (ADNR), Division of Parks and Outdoor Recreation, Office of History and Archaeology.

7.4.2 Human History

Human history addresses prehistoric through present day occupation of the North Slope and the communities of Barrow, Nuiqsut, and Kaktovik.

7.4.2.1 Barrow

Barrow is located on the Chukchi Sea coast approximately 7.5 miles (12 km) southwest of Point Barrow, the most northerly point in the United States. Point Barrow marks the boundary between the Chukchi and Beaufort Seas. The project site is approximately 200 miles (322 km) east of Barrow.

The area around Point Barrow has been inhabited for approximately 4,000 years, with continuous habitation occurring for at least 1,300 years (Dumond, 1977:32,106,112,114,131-33). The Birnirk peoples, a marine-oriented culture that practiced whaling and established small, semi-permanent coastal communities, were the earliest continuous occupants. The Birnirk peoples were followed by Thule whalers, whose dispersed coastal populations increased in numbers over time leading to large, permanent Thule villages. The establishment of these settlements marked the presence of the Thule culture, the direct ancestors of present-day Inupiat Eskimos.

Europeans first encountered the Inupiat in 1826. The Inupiat were described by visitors to the Barrow area in the mid-1800s as people who hunted marine mammals, including bowhead whale, and inland resources such as caribou. Early reports also described the Inupiat as traders who exchanged resources with people residing inland. In the 1850s, commercial whaling ships began making regular stops at Point Barrow to trade firearms, ammunition, and alcohol for baleen and furs. In the mid-1800s, permanent shore-based commercial whaling stations introduced the Inupiat to wage employment and increased trade opportunities, as well as disease (Sonnenfield, 1956:82-84).

7.4.2.2 Nuiqsut

Nuiqsut is located on the west side of the Nechelik (Nigliq) Channel in the Colville River Delta, about 18 miles (29 km) upriver from the Alaskan Beaufort Sea coast. The community lies 136 miles (219 km) southeast of Barrow and is approximately the same distance from Kaktovik to the east. The Kuparuk oil fields are about 20 miles (32 km) east of Nuiqsut, and Deadhorse (in the Prudhoe Bay industrial complex) is about 60 miles (97 km) east of Nuiqsut. Nuiqsut is the community nearest to the project site.

Nuiqsut had been a traditional hunting, fishing, trapping, and trading site used for many generations until the late 1940s, when the Bureau of Indian Affairs mandated school attendance for children, and most families on the lower Colville River delta moved to Barrow. The area, however, continued to be used for hunting, fishing, and trapping and the village was reestablished in 1973. The resettlement of Nuiqsut was inspired in part by the passage of the ANCSA in 1971, which qualified those who traditionally used an area to select village lands for resettlement. In April of 1973, 27 families left Barrow by snowmachine with many of their possessions and established a tent village on the banks of the Colville River. Permanent housing and a school, store, and village corporation office were constructed the following year (Hoffman et al., 1988:9). Nuiqsut was incorporated in 1975.

7.4.2.3 Kaktovik

Kaktovik is located on Barter Island 120 miles (193 km) east of Prudhoe Bay, 90 miles (145 km) west of the Canadian border, and 360 miles (579 km) east of Barrow. Kaktovik is the only community within the Arctic National Wildlife Refuge (ANWR) and the easternmost community of the NSB.

In August of 1827, Sir John Franklin observed 54 adults camped on Barter Island (Franklin, n.d.:146). In 1914, 30 to 40 house sites were documented on Barter Island, indicating that a village had been there in the past (Leffingwell, 1919 cited in Pedersen et al., 1985:40). The village of Kaktovik was established in 1922/1923 when a trader named Tom Gordon moved his fur trading business to Barter Island. Gordon established his post near an Inupiat settlement that had previously had little contact with Europeans. Eventually, other local people settled in the vicinity. Originally situated on a sand spit at the northeast end of the island, the community was moved several times following World War II to accommodate military construction (Jacobson and Wentworth, 1982:5). The current community faces Pipsuk Lagoon and was incorporated in 1971.

7.4.3 Overview of Archaeological Periods

The prehistoric and historic peoples who lived in the region and utilized the terrestrial and marine resources left tools and scattered artifacts throughout the area. The archaeological record extends from 7,000 years before present (B.P.) in the Prudhoe Bay area to more than 10,000 B.P. in the Brooks Range (Reanier, 1995:44). The archaeological traditions (periods) are discussed below.

7.4.3.1 Paleoindian (Paleoarctic) Tradition (Before 11,000 B.P. to 9,000 B.P.)

The Paleoarctic Tradition dates back to before 11,000 B.P. This tradition is characterized by a nomadic hunting lifestyle in which large, fluted, lanceolate points (Clovis points) were used (Forbis, 1975:21). Fluted points are characteristically found with the remains of mammoth in the central or western Brooks Range (Haynes, 1980:115). The megafauna of this time period (mastodon, bison, camels, horses, caribou, and deer) appear to have provided a dependable food source for man (Forbis, 1975:23).

7.4.3.2 Northern Archaic Tradition (9,000 B.P. to 6,000 B.P.)

Around 9,000 B.P., the Northern Archaic Tradition began as the climate grew warmer, leading to the last glacial retreat and extinction of the Pleistocene megafauna. Extinction of the megafauna and cultural adaptations such as small, side-notched projectile points, notched pebbles, end scrapers, and other tool types occurred during this time period (Chance, 1997:3). Northern Archaic sites are numerous in Alaska south of the Brooks Range.

7.4.3.3 Arctic Small Tool Tradition (6,000 B.P. to 1,500 B.P.)

Technologically sophisticated end-blades and side-blades, knives, harpoon heads, scrapers, microblades, and burins characterize the Arctic Small Tool Tradition, which began around 4,000 B.P. (Campbell and Cordell, 1975:55). The bow and arrow were first used during this period. The Norton culture, named after Norton Bay in Alaska where the type site is located, was a marine mammal culture (Chance, 1997:3). Norton peoples lived in sturdy semi-subterranean houses of rock, whale bone, and driftwood, covered with sod and lined with skins. Kayaks and skin boats (umiaq) were used for travel during summer and hand-drawn sleds were used in winter. Unrefined pottery and animal effigies and ornaments carved from ivory were identified during this tradition (Zimmerman, 1997:4).

7.4.3.4 Prehistoric Eskimo Tradition (1,500 B.P. to A.D. 1827)

The Thule culture emerged from the Birnirk culture around 1,100 B.P. and became the precursors of the North Slope Inupiat (Chance, 1997:3). This culture became the preeminent hunters of the sea, applying their creative ingenuity to develop new devices for hunting whale and walrus and to modify their clothing, allowing them to remain outdoors in cold weather for longer periods. Major subsistence activities included whaling and the associated whale harvesting ceremonies; seal hunting on ice and open water; caribou hunting with bows and arrows and probably spears; bird hunting with arrows, spears, and bolas; and fishing with spears and nets (Anderson, 1984:85).

7.4.3.5 Historic Eskimo (A.D. 1827 to Present)

Around A.D. 1826, Euro-Americans encountered the Inupiat Eskimo for the first time in recorded history. Before the first explorers arrived at the coasts and islands of northwestern and northern Alaska, some of the material goods of industrial Europe, North America, and Asia had already reached northern Alaska. Beginning in the early nineteenth century, the Inupiat and other Native Americans on the North Slope were subjected to numerous agents of cultural change. Disease, metal, alcohol, firearms, and manufactured goods were the most important influences from non-Native cultures. The coastal Inupiat suffered epidemics of measles, small pox, and influenza, causing a severe population decline in the last quarter of the 19th century. Many mountain people moved to the coast around the turn of the century, filling the void left by their coastal counterparts, and essentially restructuring the population (Lobdell, 1996:19).

7.4.4 Cultural Resources

Twenty-eight prehistoric and historic cultural/archaeological sites are known to be near the project area (Table 7.4-1). The sites are widely dispersed, and are generally located along the Alaskan Beaufort Sea coast. These and other undocumented cultural/archaeological sites contain valuable prehistoric, historic, and current cultural information that contributes to a rich and comprehensive North Slope and Inupiat history.

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There are 52 ships known to have been wrecked in the Beaufort Sea planning area (Braund, 1997). Forty of these were whaling vessels, most of which were wrecked in the vicinity of Barrow. Seven ships were freighter/trading vessels. The primary role of the remaining vessels is not known. While fewer violent storms occur in the Chukchi and Beaufort Seas compared to other areas, nearshore shipwrecks may be subject to destruction from ice movement across the sea surface, seafloor, and beaches.

There are three known cultural sites near pipeline corridors that are identified for project Alternatives 2, 3, 4, and 5. The Putuligayuk River Delta Overlook Site (XBP-007) is located on the southwest shore of Prudhoe Bay and has been excavated. Artifacts recovered from this site date from the Arctic Small Tool Tradition (6,000 to 1,500 B.P.), the Northern Archaic Tradition (9,000 to 6,000 B.P.), and the Paleoarctic Tradition (11,000 to 9,000 B.P.) indicating that this area has been used for thousands of years. A second site (XBP-019) contains three sod house ruins in the vicinity of Point McIntyre, which date from the Historic Eskimo period around 1900. The third site (XBP-040) is a Distant Early Warning (DEW) Line station at Point Storkersen. The station was operated from 1957 to 1963 as a radar and communication site. The Cold War period DEW Line system was composed of numerous stations constructed across northern Alaska and Canada which were intended to detect potential enemy attacks on North America. The DEW Line - Alaska segment was found eligible for inclusion on the National Register of Historic Places as a thematic property, which provides statutory protection under the NHPA.

In 1996, potential pipeline routes were surveyed for BP Exploration (Alaska) Inc. (BPXA) for cultural resources (Lobdell, 1996). The reconnaissance field study was performed to satisfy requirements for state, federal, and NSB permits. Lobdell also prepared a report (1994) that summarized the cultural resource knowledge for the Arctic Coastal Plain along the Alaskan Beaufort Sea. In a 1996 aerial survey along the onshore corridor, no relief that might hold discoverable cultural resources was identified. Other than the DEW Line station, the potential for cultural resources along this corridor is low (Lobdell, 1996:26). The Kuparuk River delta gravel mine site was included in the 1996 aerial survey, and no evidence of cultural resources was found (Lobdell, 1996:43).

An offshore reconnaissance survey was not performed and portions of the corridors for Alternatives 3, 4, and 5 were not surveyed. Once an alternative is chosen, the ADNR, Division of Parks and Outdoor Recreation, Office of History and Archaeology may request that a survey be performed. They will provide a letter of clearance for construction to proceed once they have determined that the construction will not disturb cultural or historical sites. If a previously unknown cultural resource is found during construction, both state and federal statutes stipulate that the federal agency and SHPO will be notified immediately. Depending upon circumstances at the time, an archaeologist may be dispatched to the site to determine if it is eligible for inclusion in the National Register of Historic Places (T. Smith - Pers. Comm., 1997:3).

7.4.5 Environmental Consequences

Impacts to cultural resources which may occur during the construction, operation, maintenance or abandonment of the project are discussed in this section. Impacts for Alternatives 4 and 5 are identical and are addressed together. Impacts for Alternatives 2, 3, 4, and 5 are summarized in Table 7.4-2.

7.4.5.1 Alternative 1 - No Action Alternative

A decision to not issue permits for development of the project would not directly affect existing cultural resources within the area. Lack of development projects would likely result in no further surveys for, or investigation of cultural resource sites in this area. Known and presently unknown archaeological and historic resources would remain undisturbed for the foreseeable future. However, they would eventually be lost due to natural decay and environmental factors such as shoreline erosion.

7.4.5.2 Alternative 2

Construction Impacts: The Alternative 2 pipeline route and the gravel mine site were surveyed entirely and no cultural resources were identified. The potential for finding sites during construction is considered low (Lobdell, 1996:43). The DEW Line station would be protected by SHPO clearance conditions, which may require that personnel remain outside of a zone around the DEW Line station. Therefore, no impacts to onshore cultural resource sites as a result of project construction are anticipated. There are no known offshore cultural resources in the project area. The likelihood of encountering offshore cultural resources is considered low, with site destruction most probably already finished or ongoing as a result of ice movement and bottom scouring. The impacts of project construction on offshore cultural resources are considered minor.

Operation, Maintenance, and Abandonment Impacts: Operation, maintenance, and abandonment activities would occur within the same area as construction activities. Since the pipeline corridor has already been surveyed, it is not anticipated that cultural sites would be discovered or affected as a result of operation, maintenance, or abandonment activities. Consequently, no impacts from project operation, maintenance, or abandonment are anticipated. The one exception would be a large oil spill, where potential impacts to cultural resources would be significant. Coastal sites would be especially vulnerable to effects from a large, offshore spill during open water. Sites outside the surveyed area could be affected because the oil would move around. An onshore or small spill would not affect sites because of their distance from the pipeline. Potential impacts to cultural resources resulting from an oil spill are discussed in more detail in Chapter 8.

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7.4.5.3 Alternative 3

Construction Impacts: As stated previously, portions of Alternative 3 were not included in the 1996 field survey and a survey may be required (per SHPO coordination and clearance) prior to constructing this alternative. Alternative 3 follows the same offshore corridor as Alternative 2. The onshore pipeline corridor crosses an unsurveyed route before connecting with an existing pipeline right-of-way between the Point McIntyre 1 Drill Pad and the West Dock Staging Pad. The Point McIntyre sod house site (XBP-019) is more than 450 feet (137 m) from the alignment, thus impacts to this cultural resource are not anticipated. The alignment then follows a portion of existing corridor from the West Dock Staging Pad to the Central Compressor Plant (CCP). The Putuligayuk River Delta Overlook site (XBP-007) is located along the corridor from the West Sock Staging Pad to the CCP; however, no impact is expected because this site has already been excavated. There also is another short, unsurveyed segment of the route near Pump Station No. 1 which is unlikely to have undiscovered cultural resources due to its proximity to existing roads and facilities. Therefore, no impacts to onshore cultural resources as a result of project construction are anticipated. There are no known offshore cultural resources in the project area. The likelihood of encountering offshore cultural resources is considered low, with site destruction most probably already finished or ongoing as a result of ice movement and bottom scouring. The impacts of project construction on offshore cultural resources are considered minor

Operation, Maintenance, and Abandonment Impacts: Operation, maintenance, and abandonment activities would occur within the same areas as construction activities. Since most of the pipeline corridor has already been surveyed for cultural resources, it is not anticipated that cultural sites would be impacted by operation, maintenance, or abandonment activities. The one exception would be a large oil spill. As discussed under Alternative 2, and in Chapter 8, coastal sites would be especially vulnerable to impacts from a large, offshore oil spill.

7.4.5.4 Alternatives 4 and 5

Construction Impacts: As stated previously, offshore portions of Alternatives 4 and 5 were not included in the 1996 field survey, and a survey may be required prior to constructing these alternatives. Alternatives 4 and 5 follow an existing pipeline right-of-way onshore between the West Dock Staging Pad and the CCP, and new impacts to cultural resource sites, such as the Putuligayuk River Delta Overlook (XBP-007), are not expected. There are no known offshore cultural resources in the project area. The likelihood of encountering offshore cultural resources is considered low, with site destruction most probably already finished or ongoing as a result of ice movement and bottom scouring. The impacts of project construction on offshore cultural resources are considered minor.

Operation, Maintenance, and Abandonment Impacts: Operation, maintenance, and abandonment activities would occur within the same areas as construction activities. Since the pipeline corridor follows an existing pipeline right-of-way, except for a short segment near Pump Station No. 1, it is not anticipated that cultural sites would be impacted by operation, maintenance, or abandonment activities. The one exception would be a large oil spill. As discussed under Alternative 2, and in Chapter 8, coastal sites would be especially vulnerable to impacts from a large, offshore oil spill.

7.4.6 Summary of Environmental Consequences

The Alternative 2 onshore alignment has been surveyed and did not contain cultural resource sites. The segment between the Alternative 3 landfall and the West Dock Staging Pad has not been surveyed, but there are no known cultural resources along this alignment. Onshore alignments for Alternatives 3, 4, and 5 all follow existing pipeline corridors, with the exception of a short segment near Pump Station No. 1, which is unlikely to contain resource sites because much of the area has been impacted as a result of transmission line construction. Therefore, impacts to onshore cultural resources as a result of construction, operation, maintenance, or abandonment activities are not anticipated; potential impacts to offshore cultural resources are considered minor. However, significant impacts to such resources may result in the event of a large onshore or offshore oil spill (Chapter 8). Contamination of important cultural resources could cause irreparable damage to historic artifacts and clean-up operations could cause physical damage to existing sites.

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7.5 LAND AND WATER USE

7.5.1 Affected Environment

This section describes land ownership status and existing, planned, and permissible land and water uses within the project area. It also addresses land and water ownership and jurisdiction, existing land and water use, land use regulations and management, consistency with coastal management, and permitting implications.

7.5.1.1 Land and Water Jurisdiction and Ownership

Ownership often determines what activities are allowed on lands and waters, and dictates management and permitting requirements for proposed activities. Portions of the onshore and offshore project area are owned or under the jurisdiction of the federal government, state government, NSB or are Native trust lands. In offshore areas, these include federal submerged lands of the Outer Continental Shelf (OCS); and state submerged lands, barrier islands, and tidelands located between the boundary of state waters and the mainland shoreline. In onshore areas, land is primarily owned by the State of Alaska ADNR, with a few parcels that are either federal reserved or Native trust lands. There are no lands or waters owned by local government or private parties in the immediate project area. Current land status in the project area is depicted on Figure 7.5-1.

Federal Submerged Lands: Federal submerged (offshore) lands in the project area consist of lands on the OCS seaward of the Alaska state boundary, generally 3 miles (4.8 km) from the mainland and barrier islands coastline. Federal submerged land and associated oil, gas, and mineral resources are managed by the U. S. Department of Interior, Minerals Management Service (MMS). The Northstar Unit includes two federal oil and gas leases (Y0179 and Y0181) located approximately 3.5 miles (5.6 km) offshore. Alternative pipeline routes from Seal Island to Point Storkersen, the area near Point McIntyre, and the West Dock causeway, do not cross federal submerged lands; however, pipelines would be in waters under federal jurisdiction.

Federal Reservations: There are two federal reservation areas on the North Slope between Barrow and the Canadian border: ANWR and the National Petroleum Reserve, Alaska (NPRA). The two federal reservations, NPRA and ANWR, are located 66 miles (106 km) southwest and 140 miles (225 km) east of the project area, respectively, and would not be affected by the project. One of the DEW Line stations, a small reservation located on the coast east of Point Storkersen approximately 6 miles (9.7 km) south of Seal Island, is located in the project area. The site, originally part of the DEW Line, is a decommissioned facility that once served as part of a defense early warning system during the Cold War Era.

State Lands and Waters: The State of Alaska has jurisdiction over, and ownership of, the majority of the Arctic Coastal Plain between NPRA and ANWR. These lands were selected as part of the State Land Grant Entitlement (Section 6A of the Alaska Statehood Act) from the federal government and are managed by the ADNR. On state lands, the state owns both the surface and the right to the subsurface estate. Mineral rights include oil and gas, as well as minerals, metals, and coal.

ADNR has jurisdiction over state waters, including offshore waters within 3 miles (4.8 km) of the coast and barrier islands, freshwater lakes, and rivers. ADNR's jurisdiction and ownership responsibilities also include tide lands (land generally located underneath navigable sea water that is exposed by tidal fluctuations) and submerged lands (land under navigable sea water not exposed during tidal fluctuations) within 3 miles (4.8 km) of the coastline. The state owns the submerged/tide land surface and subsurface estate, which also includes mineral rights. Five state oil and gas lease tracts are within the Northstar Unit.

Native Allotments: Native Allotments (sometimes referred to as Indian Trust Lands) were established under the Indian Reorganization Act of 1906, allowing Native Americans to select traditional land use sites of up to 160 acres (64.8 hectares) for private use. The use of, or lease of all or part of, an allotment by another party requires 100% consensus of all family heirs and approval of the Bureau of Indian Affairs. The four Native Allotments in the project area are shown on Figure 7.5-1.

7.5.1.2 Existing Land Use

Existing land use in the project area includes oil industry housing and administrative "base camps," oil production and processing facilities, transportation and utility corridors, and subsistence uses.

Housing and Administrative Base Camps: Housing development includes occupied and vacant dwellings, apartments, and dormitories. Large-scale residential land use within the project area is associated with oil and gas development activities and is limited to the areas of Frontier Base Camp, ARCO Base Camp, and Deadhorse. Base camp facilities include lodging, food, recreational, medical, and administrative services.

Oil Production and Processing Facilities: Oil production and processing facilities include oil development pads and platforms, processing and distribution centers, equipment maintenance and repair locations, and facilities designed for construction and storage of modules and other major oil field components.

The West Dock Staging Pad and causeway to drill site Point McIntyre No. 2 are owned jointly by a consortium of oil companies comprised of Arco Alaska, Inc., BPXA, Chevron, Exxon, Louisiana Land, Marathon, Mobil, Phillips, Shell, and Texaco. Modifications to the facilities (including the causeway) must be agreed upon unanimously by all parties.

Traditionally Used Areas: Native Allotments located in the project area would not be affected by the project. The state lands in the project area leased for oil and gas development are not open to public access. Onshore and offshore portions of the project area were traditionally used for subsistence activities. Local residents have indicated that restrictions on access have reduced subsistence activities onshore in the project area (N. Ahvakana in USDOI, MMS, 1995:16). Some subsistence use of the barrier islands still occurs, as Nuiqsut residents pass through the offshore area on their way to Cross Island.

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7.5.1.3 Land Use Regulations and Management

Land and water uses in the project area are subject to land use regulations and management plans administered by federal, state, and local government. Federal and state regulations apply to use of submerged and onshore lands. The NSB applies land use regulations to all state, local, and privately owned lands and waters within NSB boundaries, including the project area. The federal, state, and NSB governments also participate in administration of coastal management, which is discussed separately in Section 7.5.1.4

Federal Regulations: Federal land use regulations are primarily associated with federal offshore oil and gas leases and coastal management. Exploration, development, and production from federal offshore leases are subject to 30 CFR Parts 250 and 252, as well as specific stipulations attached to the lease(s) administered by the MMS.

State Regulations: The ADNR Division of Oil and Gas manages lease sales for oil and gas projects and oversees state lease tracts. The Alaska Oil and Gas Conservation Commission, on behalf of ADNR, regulates specific field operations such as well spacing, injection wells, and other aspects of reservoir management. The ADNR, Division of Land manages the surface estate, including gravel resources that are not associated with specific oil and gas lease tracts. The Division of Mining and Water Management administers the state water appropriation system, which allocates the right to use surface and subsurface freshwater. The State Pipeline Office evaluates and approves leases for pipelines and associated facilities and oversees construction and operation of all pipeline systems.

North Slope Borough Regulations: The NSB is a Home Rule municipality that is governed by state law and a municipally-adopted charter. Municipal powers adopted include platting (control over the subdivision of land) and regulation of land use, which must be based on a comprehensive plan. Platting regulations and land use controls apply within the municipal boundary, which extends to the limit of state waters in the Alaskan Beaufort Sea, and are under NSB control. A Comprehensive Plan was developed in 1984 and revised in 1996 to identify and provide direction for planning within the NSB. The plan provides the basis for the NSB's Land Management Regulations (LMRs), which establish zoning districts and performance-based land use policies. These regulations and their relationship with the project are summarized in Table 7.5-1. The portion of the Northstar Unit in state waters is also subject to NSB jurisdiction.

Policies: The intent of the NSB's Comprehensive Plan and LMRs is to maintain and protect subsistence resources (NSB, 1996:28) with responsible exploration, development, and extraction of natural resources. Compliance with this intent is accomplished through enforceable policies which follow a format common to both the NSB LMRs and NSB Coastal Management Plan (CMP), and include standards for development, required development features, policies to follow best development practices, and policies to minimize environmental impacts.

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Zoning Districts Under the Land Management Regulations: The NSB LMRs include several zoning districts that apply to lands and waters within the NSB. The project area is within two of the NSB's zoning districts, Resource Development District and Conservation District:

- The Resource Development District is designed to address cumulative impacts of large-scale development projects, such as resource extraction and related transportation and processing activities. Establishment of a Resource Development District requires rezoning from another zoning district, usually Conservation District. To receive approval for rezoning to a Resource Development District, the project must not permanently and seriously impair the surrounding ecosystem that supports plants and animals used locally for subsistence. Activities must be planned, phased, and developed as a unit or series of interrelated units, under an approved Master Plan, with provisions for all necessary public and private facilities. This Master Plan is submitted with the application for rezoning. The Master Plan must meet policies of the Comprehensive Plan and CMP, as well as any conditions of approval and special policies imposed on individual Resource Development Districts at the time of designation.

- The Conservation District includes the majority of lands within the NSB boundary. The district is designed to address management of subsistence use areas, traditional land use, and preservation of the environment. The Conservation District limits the extent of resource development activities. Uses and activities are subject to policies designed to minimize environmental impact on the North Slope.

Most of the onshore portion of the project area is within the Resource Development District and covered by various Master Plans. The offshore portion of the project area is within a part of the Conservation District which was established to protect the natural ecosystem for subsistence usages. Development of the Northstar Unit will require a rezoning from Conservation District to Resource Development District. This will require preparation and approval of a Master Plan for the project, and compliance with LMR policies. In addition, the onshore portions of the project must also be covered under the Master Plan prepared for rezoning.

7.5.1.4 Coastal Management

Coastal management is a cooperative federal, state, and local land and water use program that evolved from the federal Coastal Zone Management Act of 1972. Under guidance of the federal act, the State of Alaska passed the Alaska Coastal Management Program (ACMP) in 1977. The state program is intended to balance development and land use activities, resources, and permitting among federal, state, and local governments. The ACMP includes statewide standards that apply to development activities, identifies permits and approvals that are subject to a consistency determination with coastal management plans, establishes an interim coastal boundary where activities are subject to coastal management, and identifies the process for permit review and determination of coastal consistency. The ACMP allows municipal Alaska governments to develop their own district coastal management plans (including district-specific coastal boundaries and policy guidelines) in order to address local issues and needs. The plans are subject to federal and state procedural guidelines and must be approved by the state and federal governments before they can be implemented. The project falls within the coastal boundaries of the NSB CMP and is subject to a consistency determination with ACMP standards, including the NSB CMP policies.

Coastal management criteria must be applied during existing local, state, and federal permit reviews. The statewide ACMP standards contain regulations (6 AAC 80.040-150) addressing: coastal development; geophysical hazard areas; recreation; energy facilities; transportation and utilities; subsistence; habitats; air, land, and water quality; statewide historic, prehistoric, and archaeological resources; and other resources. The NSB has more specific CMP policies that address these topics. Applicable policies are referenced in Table 7.5-1.

A formal process, called the coastal consistency review, involves the review of permit applications by appropriate government agencies, the applicant, and the general public, to ensure compliance with ACMP standards, including the policies of approved local district plans, such as the NSB CMP. If state and/or federal permits are required, a state agency coordinates the consistency review to reach the consistency determination. Conditions or stipulations may be attached to state and local permits based on the outcome of the coastal consistency determination.

7.5.2 Environmental Consequences

The following section discusses the potential impacts of the project alternatives to land and water use resources within the project area. Impacts from Alternatives 2, 3, 4, and 5 are the same; therefore, they have been addressed together and are summarized in Table 7.5-2.

7.5.2.1 Alternative 1 - No Action Alternative

Land uses within the area have been changing in response to oil field development and are likely to continue to change, regardless of project construction. The development of new fields other than Northstar would require installation of additional pipelines and would likely require new processing facilities which could require zoning changes and would require consistency with the ACMP.

7.5.2.2 Alternatives 2, 3, 4, and 5

The only anticipated changes in land status are those related to rezoning the Northstar Unit from a Conservation District to a Resource Development District. Although Alternatives 2 and 3 would cross close to the former DEW Line installation, the federal government has conveyed ownership of the site to the State of Alaska. The rezoning falls under NSB regulations and procedures and would result in an increase in oil field development land uses on the North Slope. This impact would be minor.

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The onshore portion of the pipeline crosses access roads, several existing pipelines, and utility lines. Road closures or detours, interruption of flow through existing pipelines, or interruption of utility service would result in short-term, minor impacts to existing land use during construction.

Alternative 2 and a portion of Alternative 3 would add a pipeline across a currently undeveloped area. However, given the industrial nature of the area, this impact would be minor.

Construction of the onshore pipeline for Alternatives 3 and 4 along existing right-of-ways could cause temporary road closures or detours, interruption of flow through the pipeline, or interruption of utility service but impacts would be short-term and minor to existing land use.

For Alternative 5, the landfall is at the West Dock causeway and may require widening of the causeway, which would require agreement among the consortium of companies owning the causeway. Construction of the onshore pipeline along existing right-of-ways may cause temporary road closures or detours, interruption of flow through the pipeline, or interruption of utility service but impacts would be short-term and minor to existing land use.

The offshore portion of Alternatives 2, 3, 4, and 5 would not affect existing submerged lands. Boat traffic associated with project construction offshore could temporarily affect access to offshore subsistence use, but such impacts would be negligible. Because traditional land use of the onshore portion of the project area is infrequent, onshore construction would have a negligible impact on traditional land use. See Section 7.3 for discussion of impacts on subsistence.

The project must also undergo a coastal management consistency review and determination. In order to be consistent with the ACMP standards and NSB CMP policies, conditions may be attached to federal, state, and local permits and approvals as a result of the consistency determination.

Operation Impacts: Operation of the project would have no impact to the jurisdictional and ownership status of the project area. There would be no impacts on land use from project operation. Boat traffic associated with project operation in offshore areas could temporarily affect access to offshore subsistence use, but such impacts would be negligible. An oil spill could affect land and water resources, and impacts from a large release in the project area are discussed in Chapter 8.

Maintenance Impacts: Maintenance of the project would have no impact on the existing jurisdictional and ownership status of lands or on land use within the project area.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts would be expected to be similar to those generated during construction, and the overall impact of abandonment would be expected to be minor. For a scenario involving in-place abandonment and/or reuse of a substantial portion of the project facilities, the overall impacts of abandonment would also be expected to be minor.

7.5.3 Summary of Environmental Consequences

Unavoidable, adverse impacts as a result of changes to the status of jurisdiction or ownership were identified as minor. The onshore portion of the pipeline for Alternatives 2, 3, 4, and 5 would cross access roads, existing pipelines, and utility lines. Alternative 2 and a portion of Alternative 3 would add a pipeline across a currently undeveloped area, resulting in a minor impact to land use. Some short-term and minor impacts to land use would occur during construction due to road closures or detours, and interruptions to pipeline flow or utility service. There would be no impacts to onshore industrial land use due to project operation. Because traditional land use of the onshore portion of the project area is infrequent, onshore construction and operation would have a negligible impact on traditional land use.

There would be no impacts on use of submerged lands during project construction or operation. Boat traffic associated with project construction and operation would cause negligible impacts to boat access associated with offshore subsistence uses.

Project site lands would be used for industrial purposes. However, the area could be used for other purposes following depletion of oil and gas resources. Therefore, short-term uses of the area would not preclude returning land uses to pre-construction condition.

Designated pipeline corridors would require easements, which would exclude other uses from the area covered by specific easements. Designated easements would result in temporary commitment of resources for project development and operation. However, corridors could be used for other purposes following completion of oil and gas production; therefore, long-term effects of land use changes resulting from this project are not anticipated.

7.5.4 References

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7.6 SOCIOECONOMICS

7.6.1 Affected Environment

This section describes socioeconomic characteristics of the affected environment and environmental consequences of project alternatives. The discussion addresses socioeconomic characteristics of the State of Alaska, the NSB, Barrow, Nuiqsut, Kaktovik, and Deadhorse.

7.6.1.1 State of Alaska

Regional Setting: Alaska was purchased from Russia in 1867. On January 3, 1959, Alaska was admitted to the Union as the 49th state.

Population: Alaska's estimated population as of July 1, 1993, was 599,200, approximately 0.23% of the total U.S. population, placing Alaska 49th in state population. Alaska's population growth from 1950 to 1995 is shown on Figure 7.6-1 (ADOL, 1993:15). Alaska has a diverse ethnic population, with Caucasians making up 74.8% of the total population; Alaska Natives/Native Americans (Aleuts, Eskimos, and Indians), 16.5%; African Americans, 4.6%; and Asians and Pacific Islanders, 4.1%. In 1993, the ratio of males to females in Alaska was approximately 1.1 to 1.0, consisting of 313,354 males and 285,846 females. Approximately 78% of Alaska's population resides in the urban centers of Anchorage, Juneau, Fairbanks, Ketchikan, Matanuska Susitna Borough, and the Kenai Peninsula. The overall median age for Alaskans was 29.7 years in 1993; in 1992 the median age in the U.S. was 33.4 years (ADHSS, 1995:5-7).

Employment and Income: Alaska's economy has historically been typified by boom-and-bust cycles driven by its dependence on oil, timber, mining, fishing, and tourism. The peaks and troughs in Alaska's economy are based on seasonal employment patterns and are often dependent on events outside the state's borders (such as the decline of oil prices in 1986).

Alaska's economy grew for the eighth straight year in 1995, with the unemployment rate falling to an all-time low of 7%. The declining unemployment rate is the result of an increase in wage and salary jobs and a decrease in net migration to Alaska (ANB, 1996:62). However, the job growth rate was slower than at any other time in the last decade, largely due to lay-offs in the oil and gas industry, federal downsizing, and the closure of MarkAir airlines. Alaska's employment by industry for 1996 is depicted on Figure 7.6-2.

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Alaska was ranked 10th in the nation for per capita income ($24,182) in 1995. However, Alaska's income in relation to the rest of the nation has declined. Although the per capita income increased slightly from 1994 figures, the cost of living had a greater increase (ANB, 1996:97). In 1990, the U.S. Census Bureau noted that 9% of the Alaska population lived below the poverty level.

Fiscal Characteristics: The oil and gas industry is the largest contributor to Alaska's economy with over half of every state dollar being generated by taxes and royalties on North Slope crude oil (ANB, 1996:60). The production of oil from Prudhoe Bay oil fields peaked in 1988 and has been declining since 1991. Oil revenues will continue to decline as well (State of Alaska, 1995:1, 3).

For Fiscal Year 1996 the state budgeted $3.2 billion into the General Fund. Of that, 50% ($1.6 billion) came from oil revenues (State of Alaska, 1995:6).

7.6.1.2 North Slope Borough

Regional Setting and History: The NSB was incorporated on July 2, 1972, and adopted its Home Rule Charter on April 30, 1974. In the vicinity of the proposed project, the NSB includes the communities of Barrow, Nuiqsut, Kaktovik, and the petroleum/industrial complex of Prudhoe Bay/Deadhorse (Figure 7.6-3). Arctic Slope Regional Corporation is the regional for-profit Native corporation under the provisions of ANCSA.

Population: According to the 1993 NSB Census of Population and Economy, which provided the last comprehensive analysis of population trends, the NSB had a total resident population of 6,538. The NSB population grew 56% from 1980 to 1993. Historic population for the NSB from 1939 through 1990 is shown on Figure 7.6-4. The population in 1993 was 74% Inupiat, 17% Caucasian, 6% Asian/Pacific Islander, 2% Native American, and 1% was identified as other minority (Harcharek, n.d.:NSB-5, 9).

Employment and Income: As noted in Section 7.3.1.1, communities on the North Slope maintain a mixed cash/subsistence economy. The subsistence economy of the North Slope is described in that section. The NSB cash economy is dominated by local government, the school district, and ANCSA Native corporations (Figure 7.6-5). The NSB is the largest employer of North Slope residents, employing more than 46% of all working residents, and the school district employs more than 18% of working residents. Only a small number of NSB residents are employed by the oil industry (USDOI, MMS, 1996:III-C-8), although oil companies actively recruit from local communities and provide training.

The NSB has experienced problems with high unemployment and underemployment rates related to population growth. Causes of low employment rates include limited employment opportunities in many villages, natural population increases to the area, and migration of individuals from other parts of Alaska and the lower 48 states. The NSB's 1993 unemployment rate was 11.32% (Harcharek, n.d.:NSB-28).

The average NSB household income in 1993 was $54,645, and per capita income was $15,218. The average Inupiat household income was $44,551, with per capita income at $10,765. The average non-Inupiat household income was $74,448, and per capita income was $29,525.

Fiscal Characteristics: The NSB collects property tax revenues from petroleum industry facilities. The mill rate applied to assessed property in Fiscal Year 1996/97 was 18.5 mills; 4.96 were for operations and 13.54 were for debt service (NSB, 1997:23). Improved education, health, and other government services have been funded by tax revenues. An extensive capital improvements program, which has resulted in numerous construction jobs for permanent residents, also has been financed by tax revenue.

The financial structure of the NSB relies heavily upon revenues from oil-related activity within the borough. In 1996, the total full value of oil and gas property within the NSB totaled $12,130,115,480 (ADCRA, 1997:23). Revenue to the NSB from oil and gas property tax revenues accounted for $224,289,817, more than 98% of total tax revenues and more than 68% of total revenue for 1996. Tax revenues from oil and gas property allow the NSB to finance many projects through general obligation bonds. The total NSB general obligation debt in 1996 totaled $881,287,031. With the NSB's relatively small population, this level of general obligation per capita debt was the highest in Alaska.

Total budgeted revenue in Fiscal Year 1996/97 was estimated at $331 million (NSB, 1997:32). Property taxes (71%) were the largest source of these revenues, and nearly all property taxes (97%) were paid by the petroleum industry. Depending on world energy prices, property values could be higher or lower than projected but are not likely to be a constraining factor for future revenues.

7.6.1.3 Barrow

Regional Setting: Barrow is the NSB economic center and largest city in the NSB. From 1990 to 1993, Barrow experienced an annual growth rate of 4.27%, compared to the 3.7% rate of growth of the NSB in the same time period. Almost all the growth can be attributed to migration to Barrow (Harcharek, n.d.:NSB-5).

Population: Barrow's population in 1993 was estimated at 3,908, ranking Barrow as the 12th largest city in Alaska (Harcharek, n.d.:NSB-5). Barrow's population growth from 1939 to 1990 is shown in Figure 7.6-4. Barrow's size and ethnic composition is unique among the eight villages on the North Slope; it is the largest village and contains the highest proportion of non-Natives.

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Figure 7.6-4 (page 1 of 2)

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Population comparisons in 1993 showed that 52% of Barrow's population was male, and 48% was female. Forty-six percent of the population was between 27 and 59 years old. The largest ethnic component of the population in 1993 was Inupiat (61%), followed by Caucasian (24%), Asian/Pacific Islander (10%), other Native American (3%), African American (1%), and Hispanic (1%).

Employment and Income: The labor force in Barrow in 1993 consisted of 2,258 workers, with 217 unemployed. According to the NSB 1993/94 Economic Profile and Census Report, 41.9% of the labor force was Inupiat, 38.4% Caucasian, and 19.7% other minorities. The public sector employed 64% of the working population, indicating that the NSB continues to be the major employer in Barrow (Figure 7.6-5) (Harcharek, n.d.:BRW-1, 6, 15).

The average household income in 1993 was $63,896. Inupiat household incomes averaged $53,649, while non-Inupiat household incomes averaged $75,084. Inupiat incomes experienced slightly more growth (2.66%) than non-Inupiat incomes (1.79%) from 1988 to 1993 (Harcharek, n.d.:BRW-22).

7.6.1.4 Nuiqsut

Regional Setting: Nuiqsut is approximately 60 miles (97 km) west of the Prudhoe Bay industrial complex, on the west bank of the Nechelik Channel in the Colville River Delta. The community was re-established in 1973 at the site of an abandoned, traditionally-used village. Permanent housing was constructed gradually, and Nuiqsut was incorporated in 1975.

Nuiqsut has no access to permanent, year-round roads that connect to the rest of the state or other communities in the borough. However, surface access is possible by snow machine to Prudhoe Bay/Deadhorse during winter. Marine access is available for a limited time in summer when the ice-pack in the Beaufort Sea moves away from the coast. Primary access to the community is by regularly-scheduled daily air service from Barrow and Deadhorse.

Population: The Alaska Department of Labor reports Nuiqsut's population was 410 as of July 1, 1995. Nuiqsut is characterized by a very young population, with approximately 44% of the 1993 population under the age of 15. Approximately 10.8% of residents are between the ages of 25 to 29. The population is predominantly Inupiat (more than 90%). Nuiqsut's population growth from 1939 to 1990 is shown on Figure 7.6-6.

Employment and Income: Historically, Nuiqsut's economy was based largely on subsistence activities. A cash economy developed with re-establishment of the community in 1973. The public sector and Kuukpik Corporation, provide most of Nuiqsut's employment (Figure 7.6-7). Unemployment was estimated at 5.21% of the total labor force, although there was no unemployment for those in the 18 to 26 age group.

The average household income in 1993 was $39,180; per capita income was $9,637. Inupiat household income and per capita income were lower than non-Inupiat incomes. Typically, non-Inupiats are employed as school teachers or managers in the village corporation, accounting for their higher household and per capita incomes.

7.6.1.5 Kaktovik

Regional Setting: Kaktovik is located on Barter Island, approximately 120 miles (193 km) east of Prudhoe Bay. The village was incorporated in 1971 and was one of the original North Slope villages awarded land under ANCSA. Kaktovik is a traditional Inupiat community and participates in a variety of subsistence activities. Employment opportunities are limited; primary employers are the NSB, the City of Kaktovik, and the Kaktovik Inupiat Corporation.

Population: In 1939, Kaktovik's population was estimated at 13 (U.S. Census). Construction of the DEW Line radar station caused the population to almost triple from 1950 to 1960, and the 1990 population of 224 represented approximately 3.5% of NSB total population. Inupiat residents comprised 86% of the total population in 1993. Kaktovik's population growth from 1939 to 1990 is shown in Figure 7.6-6 (Harcharek, n.d.:NSB-15).

Employment and Income: According to the 1993 NSB Census of Population and Economy, the public sector employed 71% of the labor force (Figure 7.6-7). The local village corporation and the private sector employed most of the remainder of the work force.

Findings from a 3-year study (1991 to 1993) investigating the sociocultural consequences of OCS development in Alaska estimated Kaktovik per capita income to total $18,176. The average household income was $55,688 (Pederson, 1995:XX1-5).

7.6.1.6 Prudhoe Bay/Deadhorse

Regional Setting: Prudhoe Bay was developed initially for oil production operations in the 1970s and 1980s. The 800-mile long TAPS, was constructed in the mid-1970s to transport crude oil from Prudhoe Bay to Valdez, where marine tankers load the product and ferry it to terminals on the U.S. West Coast and other locations.

The unincorporated community of Deadhorse was developed as a result of oil discoveries and is the primary land service base for oil and gas development in the Prudhoe Bay area. A workforce of 5,000 rotates in and out of the Prudhoe Bay area on a fixed schedule. Most oil-related employees work 12-hour shifts for 7 days a week. Deadhorse has not been incorporated as a municipality under Alaska Statute, and ANCSA Native corporations were not part of its formation.

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Figure 7.6-7 (page 1 of 2)

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Population: Most of the population of Deadhorse is not considered to be permanently resident, and the number of people present at any given time is influenced directly by oil field activities. According to the 1990 U.S. Census of Population and Employment, 47 permanent residents were living in the Prudhoe Bay/Deadhorse area.

Employment and Income: Census figures in 1990 showed no unemployment, with 28 persons employed by the private sector in industries such as travel and tourism. The median household income in 1996 in Deadhorse was $102,264. As indicated above, a non-resident work force of approximately 5,000 rotates in and out of the area.

7.6.2 Environmental Consequences

Analysis of socioeconomic impacts has been included in this EIS to evaluate potential effects of the project on population, employment, income, and public finance/fiscal characteristics. Impacts from Alternatives 2, 3, 4, and 5 are identical; therefore, they have been addressed together and are summarized in Table 7.6-1. The range of effects from an oil spill would be variable and would include costs for cleanup activities, which could affect the local and state economics. Potential impacts of an oil spill on socioeconomic resources are addressed in Chapter 8.

7.6.2.1 Alternative 1 - No Action Alternative

For the No Action Alternative, there would be no impacts on population, employment income, and public finances, nor would there be fiscal impacts. The $611 million in state revenue, $392 million in federal revenue, and $64 million in NSB revenue estimated from Northstar oil and gas production would not be generated through royalties, income taxes, and property taxes that would accrue over the life of the project. A total of 830 operation and construction jobs, which would generate approximately $307 million in wages, would not be created. Past experience with oil field development projects has indicated a minimum of one-to-one correlation between direct and indirect man-hours for every man-hour of direct labor expended, which also would not be realized if the project were not constructed.

7.6.2.2 Alternatives 2, 3, 4, and 5

Fiscal Impacts: Fiscal impacts of the 158 million barrels of oil production under Alternatives 2, 3, 4, and 5 include the potential state, federal, and local revenues that would result from the project. Revenues to the state, federal, and local (NSB) governments come from a number of royalty and tax payments. These revenues are based on gross income from the project (royalties), capital investment (ad valorem tax), and net income (federal income tax). Estimates of the recoverable oil from the Northstar Unit have ranged from 145 million barrels to 172 million barrels; therefore, a mid-point estimate of 158 million barrels was used for analyses. Peak production would be achieved in the second year

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at a production rate of 65,000 barrels per day (barrels/day). After 3 years, the production rate will decline according to the profile shown in Figure 7.6-8 (Hanley, 1997a:2).

Factors influencing fiscal impact analysis results include the amount of recoverable oil, total capital and operating expenditures, estimated Alaska North Slope wellhead prices, and the ratio of state revenue to total gross revenue.

Methodology: An existing ADNR model was used as the basis for calculating state and federal revenues from the Northstar Project (ADNR, 1996:c). The ADNR model was updated to reflect the updated production scenario and current price forecasts for North Slope oil during the period from 2000 through 2014. The gross revenues were calculated using the Fall 1998 long-term oil price forecast from the Alaska Department of Revenue. Gross revenues for the 158-million-barrel model were calculated based on a production estimate of 65,000 barrels/day (ADR, 1996:31) for 3 years, after which the daily production rate declines by 35% every year.

Analysis Results: The analysis provides estimated revenues to the state, federal government, and NSB that would result from Northstar Unit development. Estimates are based on total recoverable reserves over the life of the field.

State Revenue: State revenues from the project recoverable reserves of 158 million barrels total $ 478.6 million over its anticipated 15-year life and are depicted in Table 7.6-2. This represents 25.0% of total gross project revenue. State oil and gas royalties would capture 16.11% of the total gross revenue. Other revenues and state supplemental royalties, state share of federal royalties, severance tax, spill and conservation tax, ad valorem tax, and income tax would contribute the remainder of the state revenue.

The ad valorem tax revenues to the state and NSB were calculated using the current taxation rates for the NSB and the remaining state share of ad valorem tax revenues. The capital investment assumption for the project totals $343.5 million of the total project cost of $405 million (Hanley, 1997a).

Federal Revenue: Depending on the actual location of oil produced with regard to state and federal lease tracts, and the outcome of discussions between State of Alaska and the MMS on royalty share, some oil and gas royalty revenues will be generated to the federal government. Table 7.6-2 shows the federal revenues by year for the life of the project. These revenues were calculated using the updated ADNR model. Federal revenues from the project would total $306.3 million.

NSB Revenue: Using capital expenditures provided by BPXA, analysis shows revenue from the project in its initial year would contribute approximately $6.35 million (a 3% increase) to the NSB. Over the life of the project, total property tax revenues to the NSB would be $ 64.3 million, while the state portion of the ad valorem tax would total $ 5.21 million (Figure 7.6-9).

The total ad valorem tax for the NSB and state was derived by using total capital expenditures with some slight modifications. Total project capital expenditures would be $405, including initial development drilling. The $405 million figure assumes a capital cost estimate of $271 million, with $82 million for drilling, and $52 million for pipeline construction. Ad valorem taxes to be paid would be based on the total capital investment of $405 million, adjusted to $343.5 million to reflect the non-tangible drilling costs. This property value would be depreciated over the life of the project (Hanley, 1997b:3). The State of Alaska would make a determination of the depreciation rates; however, for purposes of this evaluation, a straight-line depreciation over 15 years has been assumed, equivalent to a rate of 6.67% a year, modified for an inflation factor over the life of the project. The respective ad valorem tax revenues under these assumptions are shown on Figure 7.6-9.

The estimated $64.3 million in revenue to the NSB generated over the life of the proposed action would constitute a beneficial impact to a special population as defined under Executive Order 12898 regarding Environmental Justice. This revenue would contribute to providing NSB services and facilities in communities affected by the proposed action, and contribute to their ability to maintain a mixed cash/subsistence economy.

Economic benefits from the Northstar development will support NSB residents in three primary ways: education, employment/contracts, and ad valorem property taxes.

First, new development will create new job opportunities in oil field construction, maintenance, operations, and support services. In support of the new job opportunities, BPXA and the Arctic Slope Regional Corporation (ASRC) have joined together to form “Itqanaiyagvik” which is comprised of six development programs designed to train NSB residents for jobs in the oil and gas industry.

Second, the Northstar project includes two ASRC subsidiaries, Houston Contracting and Alaska Petroleum Contractors, who would gain in revenue approximately $60 million. Both of these contractors are integral participants in the Northstar Project through their respective roles as the pipeline installer and fabricator of process module components. In addition, Nuiqsut’s village corporation, Kuukpik, will provide transportation and shipping services through their joint venture - Kuukpik Carlile.

Third, the Northstar project will pay approximately $64.3 million dollars in ad valorem property tax directly to the NSB over the projects estimated 15-year field life. New oil field investments and investments which extend the lives of existing oil fields provide the source from which the NSB bond’s against.

In addition, Anchorage would receive property taxes for 1998 and 1999 during construction of some of the production modules. The revenue to Anchorage during these 2 years is estimated to be $3 million.

Project Expenditures: The total capital cost of the project is estimated to be $405 million. Excluding the $150 million for specialized materials from outside

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Alaska, 85% of that capital cost is expected to be spent in Alaska (Hanley, 1997b:3). The money spent in Alaska includes fabrication of modules and other project components, engineering services, pipeline construction, civil construction, and North Slope installation work. Direct operations costs are estimated to exceed $390 million, all of which would be spent in Alaska, as it is anticipated that supplies, camp services, and other operating expenditures would be purchased or contracted through Alaskan vendors.

In addition to the direct benefits to the state, federal, and NSB governments, there would be secondary impacts to the economy as a result of project expenditures. The job-creating impacts of these expenditures are the "multiplier effects." The secondary employment and income effects of the Northstar project expenditures on the economy of Alaska have not been determined. Historical project experience in Alaska (Hanley, 1997b:1) has demonstrated that for every direct man-hour expended there is at least one man-hour of indirect labor expended.

Construction Impacts:

Workforce: The project is estimated to generate as many as 730 jobs for Alaskans during the 18-month construction phase (BPXA, 1997:Table 1.2-4; Hanley, 1997b:1). It is assumed that a small portion (10%) of the workforce would be Alaska non-residents, who would temporarily reside in the Anchorage or Fairbanks area during the construction phase, and would represent a negligible impact to population. No population increases are anticipated within the NSB.

Employment and Income: Historical project experience in Alaska (Hanley, 1997b:1) has demonstrated that for every direct man-hour expended there is at least one man-hour of indirect labor expended. Construction of the facilities modules, the flare tower, and other project components would generate approximately 250 jobs in Anchorage over an 18-month construction period. North Slope employment demands will peak at approximately 375 workers during ice road and island construction and pipeline installation, and would require approximately 50 workers for drilling production. The majority of the workforce would be hired through contractors. Total construction requirements are estimated at approximately 2,140,000 man-hours and would generate approximately $51.6 million in Alaskan wages. Table 7.6-3 illustrates the average Alaska labor requirements, estimated duration, primary contractors, workforce location, direct man-hours, and estimated wages for the project.

Workforce composition is contingent upon several factors, including specific job requirements, availability of personnel, and local hiring policies. Historically, workers in the oil fields have come from urban centers of Alaska, and the number of NSB Native residents working directly for oil companies in or near the Prudhoe Bay industrial complex has been small, approximately 60 out of the 6,000 workers (1%) (Marshall, 1993:7).

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The overall impact from construction of the project would have a beneficial effect on employment levels and income of Alaska residents.

Operation Impacts: The operational workforce of approximately 100 would be employed at the Seal Island facilities, ice road maintenance, and onshore facilities following completion of drilling and through the 15-year life of the operation. The 100 average annual full-time jobs would generate approximately $255 million in wages, for a beneficial impact to the Alaska economy.

Maintenance Impacts: Additional maintenance workers would be assigned to Seal Island as needed from BPXA's existing work force without the creation of new jobs. No impacts to population, employment, and income are expected.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. An abandonment scenario involving removal of the facilities and infrastructure would most likely employ Alaska contractors and result in a minor, beneficial impact. An abandonment scenario involving in place abandonment and/or reuse of a substantial portion of the project facilities would result in a negligible, beneficial impact to the Alaska economy.

7.6.3 Summary of Environmental Consequences

If the project were not implemented, local, state, and federal revenues would continue to be generated by oil and gas projects. However, an incremental increase in revenues from the project would not become available to the taxing authorities.

Project construction and operation would have a beneficial impact to employment and would substantially increase tax and royalty revenues to local, state, and federal governments through oil production. Short-term benefits would result from the creation of construction jobs for gravel mining, island reconstruction, facilities fabrication, and drilling. Project construction would generate 730 Alaska construction jobs with estimated wages of $52 million. Long-term benefits would result from the addition of operations personnel and the generation of tax and royalty revenues. Project operation would generate an average of 100 Alaska operation jobs annually, with estimated wages of $255 million over a 15-year project life. Total project revenues from oil and gas royalties and taxes are estimated at up to $478.6 million to the State of Alaska, $306.3 million in federal revenue, $64.3 million to the NSB and $3 million to the Municipality of Anchorage over the 15-year project life.

The impacts of a large oil spill are discussed in depth in Chapter 8. A large oil spill could result in direct socioeconomic impacts. An oil spill could result in loss of revenues and increased costs to BPXA and the state and federal governments, depending on the size and duration of the spill event. Oil spill response and cleanup measures would likely generate short-term, high-wage employment. This could adversely effect services in local communities by temporarily attracting members of the local workforce from other jobs to cleanup efforts.

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7.7 TRANSPORTATION

7.7.1 Affected Environment

Construction, operation, maintenance, and abandonment of the project would require movement of personnel, equipment, materials, and supplies that could affect highway, air, marine, and rail facilities. Oil produced by the proposed project would be transported by the TAPS, operated by the Alyeska Pipeline Service Company. Major facilities that would be affected are shown on Figure 7.7-1. Materials coming into Alaska

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would be transported by rail, truck, barge, and/or air to the project site. Personnel would be transported to the Prudhoe Bay industrial complex via air, and then to the project site.

7.7.1.1 Marine Transportation Systems

Many of the supplies and equipment transported to the North Slope pass through Seward, Whittier, and Anchorage ports (Figure 7.7-1). The Port of Anchorage, which is the most northern deep draft port in the United States and is open year-round, has five terminals that provide service for every type of standard cargo vessel and for specialized carriers. Container cargo is the primary business activity at the port and has been increasing at a constant annual rate of approximately 1.5% over the last 10 years (Port of Anchorage, 1997:5). The port has handled approximately 2.5 to 3 million tons (2.3 to 2.7 million metric tons) of goods annually since 1994 (Mayer - Pers. Comm., 1997).

The Port of Seward handles container shipments, general cargo, and bulk cargo that transfer to rail, road, and air transportation systems. The Seward port accommodates mostly cruise ships, with some transfer of logs, pipe, and coal (Northern Stevedoring - Pers. Comm., 1997). Freight tonnage through the port totaled approximately 31,000 tons during 1996 (White - Pers. Comm., 1997).

The Port of Whittier is owned and operated by the Alaska Railroad Corporation (ARRC) and is a part of ARRC's interline system, which provides rail/barge service between Seattle and Whittier. In 1996, interline business increased by 29% and contributed 32% of ARRC's total freight revenues (ARRC, 1996:6). Freight offloaded at the port during 1996 totaled approximately 300,000 tons (White - Pers. Comm., 1997).

Marine transportation to the North Slope is limited to a seasonal window between late July and early September when the North Slope coast is ice-free. Port facilities on the North Slope range from shallow draft docks with causeway road connections to facilities located at Prudhoe Bay, to beach landing areas in North Slope communities (USDOI, MMS, 1986:426). Cargo ships and ocean barges typically are offloaded to shallow- or medium-draft ships for lightering to shore. Small craft are used to transport cargo up river to areas not located on the coast. Marine sealifts are scheduled as needed to bring oil field supplies and equipment to the Prudhoe Bay industrial complex by way of two docks on the West Dock causeway. A third dock is available at Endicott for off-loading supplies. The number of barges in each sealift (Table 7.7-1) has ranged up to 47 (Toruga - Pers. Comm., 1996). The shallow water at East Dock is used for unloading shallow draft barges in the Prudhoe Bay area.

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The Valdez Marine Terminal is the southern terminus of the TAPS and is the point from which North Slope Alaskan crude oil is transported to world markets. The terminal has 18 crude oil storage tanks with a total capacity of 9.18 million barrels. Facilities include a multi-berth, offloading facility that fills tankers, a ballast water treatment facility, power generation equipment, and vapor recovery incinerators.

7.7.1.2 Alaska Railroad Corporation

The ARRC has dock and handling yards at Seward, Whittier, and Anchorage ports to provide ground transportation of materials reaching Alaska by barge. The ARRC provides freight services from these ports to Fairbanks, where materials can be offloaded to trucks for road ferrying to the Prudhoe Bay complex.

Cargo shipment is ongoing throughout the year, although shipment of some commodities such as sand and gravel are seasonal. Major commodities transported by rail include sand and gravel, coal, refined fuel products, pipe, and pipe fittings. Smaller quantities of chemicals, machinery, equipment, and other materials also are transported. The ARRC is capable of handling large, heavy, and oversized loads, such as construction modules.

7.7.1.3 Highway Transportation Systems

The Seward Highway serves the Port of Seward, and the Glenn, Parks and Richardson Highways link Anchorage to Fairbanks. Materials, equipment, and supplies would be transported from Fairbanks to the Prudhoe Bay industrial complex via the Dalton Highway, which is the highway system most likely to be affected by the project.

The James Dalton Highway (commonly referred to as the Haul Road or Dalton Highway) is the only ground transportation route connecting Prudhoe Bay to Alaska's other major highway systems. The roadbed is 28 ft (8.5 m) wide with 3 to 6 ft (1 to 2 m) of gravel surfacing throughout the 416 miles (670 km) from Livengood, approximately 80 miles (129 km) north of Fairbanks, to Deadhorse (Figure 7.7-1). The highway was opened for public access in 1996 as far as Deadhorse. Permits from the oil field operators are required for access past Deadhorse into the Prudhoe Bay industrial complex.

Trucks, transporting commercial freight in support of oil field activities at Prudhoe Bay, dominate traffic along the Dalton Highway; however, privately owned vehicles and commercial tour operators also use the highway. Alaska Department of Transportation and Public Facilities annual average daily traffic counts along the Dalton Highway for 1992 through 1995 are shown in Table 7.7-2. The average daily number of vehicles crossing

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the Yukon River checkpoint in 1995 was 269, of which approximately 56 were visitors traveling the highway in private vehicles (Robbe, 1996:70).

7.7.1.4 Aviation Transportation Systems

The Prudhoe Bay industrial complex is served by the Deadhorse Airport, the Prudhoe Bay airstrip, and the Kuparuk airstrip (Figure 7.7-1). Alaska Airlines and Shared Aviation Services (operated by Arco Alaska, Inc.) each provide daily service to Deadhorse from Anchorage and Fairbanks (LFA, 1996:72), with an estimated 200,000 passengers transported to and from Deadhorse annually (Nickles - Pers. Comm., 1996). Commercial cargo service is provided into Deadhorse by Northern Air Cargo. The amount of cargo transported annually via air to the North Slope is estimated at 648 tons (St. John - Pers. Comm., 1996).

7.7.1.5 Pipeline Transportation Systems

Crude oil is collected from the North Slope oil fields and transported via the TAPS to Pump Station No. 1 at the northern terminus of TAPS. From this point, TAPS extends more than 800 miles (1,287 km) to the southern terminus at Valdez, located on Prince William Sound (Figure 7.7-1).

At the start-up of TAPS operation in 1977, the pipeline capacity was 300 to 500 thousand barrels/day with eight pump stations in operation. Construction of two additional pump stations, modifications to other stations, and the injection of drag-reducing chemicals has increased the pipeline's capacity to 2.2 million barrels/day.

Production projections for North Slope oil to the year 2015 show a steady decline in oil flow. North Slope production peaked at approximately 2 million barrels/day oil in 1988. Estimates for 1997 to 2015 range from 384,000 to 1.38 million barrels/day (Tyson, 1996:8). Daily production rates during the period from 2000 to 2015 (in 5-year increments) have been forecasted, as shown below, using expected production from all Prudhoe Bay area fields.

Year	Barrels/Day Oil
2000	1,120,000
2005	801,000
2010	560,000
2015	384,000

Because of declining North Slope oil production, Alyeska Pipeline Service Company has scheduled three pump stations to be shut down between the latter half of 1996 through the end of 1998 (APSC, 1996:30). Pump stations that have been shut down can be re-activated if flow rates increase. The recommissioning process could take several months; however, it is expected that the pipeline flow could be increased immediately by the use of large amounts of drag-reducing chemicals. The pipeline is capable of operating at 1.75 million barrels/day, despite the shutdown of the three pump stations.

7.7.2 Environmental Consequences

Impacts to transportation which may occur during the construction, operation, maintenance, or abandonment of the project are discussed in this section. Potential impacts to transportation for Alternatives 2, 3, 4, and 5 are identical, addressed together, and are summarized in Table 7.7-3.

7.7.2.1 Alternative 1 - No Action Alternative

Highway, aviation, marine, and rail transportation systems within the State of Alaska historically have provided support for new field development and ongoing operations in the Prudhoe Bay area. Transportation of equipment and supplies along the Dalton Highway is expected to continue, regardless of the development of the project. Alaska Airlines and Shared Aviation Services currently provide passenger service to Deadhorse in support of ongoing oil field operations. It is likely that the level of service would continue to meet transportation needs as future demands dictate. Two dock facilities currently are available at West Dock and a third dock at Endicott could be made available to meet future oil and gas-related project requirements.

Cargo handling through the Port of Anchorage has increased an average of 1.5% annually over the past 10 years, a trend likely to continue regardless of development of the project. Throughput at the Port of Whittier increased approximately 29% in 1996 from 1995 levels. Although future increases are likely to be less than the 1996 rate, rail connections at the port and construction of a new highway tunnel to Whittier ensure continued use of the port. Crude oil transport from the Port of Valdez has been declining, commensurate with declining oil production from the North Slope, and it is likely that the decline will continue.

7.7.2.2 Alternatives 2, 3, 4, and 5

Transportation service, facility, and equipment requirements for passenger and material movement would be consistent among the alternatives. Although variances in some construction materials and supplies would be expected, the subsequent differences in freight handling and transportation requirements are too small to predict.

Construction Impacts: Construction impacts to transportation result from the transportation of workers, materials, and supplies to the North Slope, and to and from Seal Island and pipeline construction sites.

Project construction would result in short-term increases in passenger airline traffic. Shared Aviation Services and Alaska Airlines already provide service between Anchorage, Fairbanks, and Deadhorse. Construction

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workers for the project are expected to represent less than 4% of the existing passenger load; therefore, transporting project workers is expected to represent a minor impact to passenger air travel.

The Ports of Anchorage, Whittier, and Seward and the Alaska Railroad have facilities sufficient to meet increased demands. Construction equipment and materials would arrive in Alaska via barge at the Ports of Anchorage, Whittier, and Seward. During the first year of construction, an estimated 2,500 tons (2,268 metric tons) of sheet pile and 5,600 tons (5,080 metric tons) of pipeline would be transported through the Port of Seward (T. Barnes - Pers. Comm., 1997). This represents approximately 26% of the current freight throughput.

Construction materials, equipment, and drilling supplies would be shipped through the Port of Whittier. Over the first 4 years of construction and operation, 5,478 to 16,314 tons (4,970 to 14,800 metric tons) would be shipped. This volume would represent 2% to 5% of the current Whittier throughput. Approximately 1,500 tons (1,361 metric tons) of project-related freight would be shipped through the Port of Anchorage during the first year of construction, representing less than 1% of the current 2.5 to 3 million tons (2.3 to 2.7 million metric tons) of throughput. With expected freight through the three ports ranging from less than 1% to as much as 26% of current levels (T. Barnes - Pers. Comm., 1997), impacts to the facilities are expected to be minor.

Equipment and materials would be transported to Fairbanks via the Alaska Railroad, or by truck on the Seward, Glenn, Parks, and/or Richardson Highways. North of Fairbanks, equipment and materials would be transported along the Dalton Highway by truck. Recent traffic counts indicate approximately 270 vehicles use the Dalton Highway daily. Traffic levels are expected to increase by two trucks per day during the 1-year construction period (T. Barnes - Pers. Comm., 1997), which represents less than 2% of current vehicle usage (assuming roundtrip traffic). Peak traffic months would be January, March, and August. Therefore, impacts to traffic movement are expected to be minor.

Major components of the process and infrastructure modules would be transported by barge from Anchorage to Seal Island or to Prudhoe Bay. A maximum of three barges would be required to transport equipment from Anchorage to Seal Island. Previous construction activities within the area have required the use of as many as 46 barges in a season, and sufficient barge capacity is available through existing sources to support transportation requirements for this phase of project construction. Consequently, impacts are expected to be minor.

Construction of the island and installation of facilities on the island would require approximately 60 workers to be transported to the island daily via four daily helicopter flights over a 3-month period during the summer construction period. No impacts to transportation are anticipated because boat and helicopter traffic are unlikely to affect existing aircraft and boat movement in the area.

Operation Impacts: Drilling personnel would be transported daily to Seal Island by helicopter or boat during drilling mobilization. Barges would be used to transport drilling materials and supplies from West Dock. A total of 21 barge trips are anticipated during drilling mobilization, including 5 to 6 barge trips from West Dock to transport the drill rig. Additionally, the resupply of materials and supplies would be transported by truck over ice roads during winter and by barge during open water seasons. Transport of personnel, materials, and supplies for drilling is expected to have a negligible effect on existing local transportation systems. Therefore, impacts are expected to be negligible.

Approximately 100 workers would be required during the project drilling operations and through the 15-year life of the operation. Personnel and supplies would be transported via air, bus, and water. Potential impacts to subsistence resources caused by the transportation of personnel and supplies to and from Seal Island are discussed in Section 7.3.

Employees would be transported to and from Deadhorse via Shared Aviation Services and Alaska Airlines. Based on current availability of flights and anticipated numbers of project personnel, impacts on air transportation facilities and services are expected to be negligible. Additionally, transportation of workers from Deadhorse to Seal Island would be by bus over an ice road during winter (late December to May), crew boats or barges during open water periods, and by helicopter during other periods, utilizing transportation services supplied by BPXA. However, because employees would be housed on Seal Island, transportation requirements for a personnel movement would be limited to periodic crew replacements. Related impacts to bus, boat, and helicopter transportation facilities would be negligible.

The island is designed to support a 4-month supply of materials. Frequently needed supplies include diesel fuel, chemicals, and consumables, including perishables (i.e., food, potable water) and non-perishables (i.e., paper goods). Diesel fuel and chemicals would be transported to Deadhorse by truck then over an ice road to the island during winter, or from West Dock to the island by barge during the open water season. Low sulfur diesel fuel may also be obtained from sources outside the Prudhoe Bay area and transported to Seal Island by barge or truck. Consumables would arrive in Deadhorse by truck or air freight and be transported from Deadhorse to the island by truck over an ice road during winter, barge during summer, or by helicopter during breakup and freezeup. The amount of supplies required to support the project would be nominal compared to the larger projects in the area. The existing transportation services are sufficient to accommodate project transportation needs, and impacts are expected to be negligible.

Approximately 30 additional tankers per year would be required to transport Northstar Unit oil during the initial years of peak production (using gas cycling and assuming each tanker holds 800,000 barrels of oil), and decreasing to approximately two tankers during the last year of production. Based on existing and projected pipeline throughput during the 15-year production period, production from the Northstar Unit would represent approximately 3.7% to 4.3% of the crude oil shipped through TAPS and the Valdez Marine Terminal during the first years (years 2, 3, and 4) of production, and approximately 0.03% of the crude oil during the 15th year of production (Section 4.4.2.4).

As discussed in Section 7.7.1.5, the amount of oil produced on the North Slope is declining. The increased amount of oil produced because of the project and transported through TAPS would represent a beneficial impact to this transportation facility.

A large oil spill can be expected to have minor impacts on transportation services and facilities in the project area and throughout Alaska due to commitment of transportation resources during the initial phases of spill response. Impacts to transportation resources due to an oil spill are discussed in Chapter 8.

Maintenance Impacts: Routine maintenance of Seal Island facilities and equipment (offshore and onshore) would result in periodic movement of personnel, materials, and equipment. The frequency and magnitude of such activities are expected to be low and related impacts to transportation systems are expected to be negligible and temporary.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental effects of the abandonment alternatives. The current transportation system is more than sufficient to handle the minor impacts associated with project abandonment. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts would be expected to be similar. For a scenario involving in place abandonment and/or reuse of a substantial portion of the project facilities, the overall impacts of abandonment would be expected to be minor.

Removal of equipment from Seal Island and removal of pipelines and vertical support members from onshore locations could require an increase in use of barge and truck transportation activities on Alaskan highways, airports, and ports. Although it is likely that some equipment and materials would remain in the Prudhoe Bay area for use at other production sites, barges and trucks could be used to move equipment to Fairbanks, Anchorage, and elsewhere. Decommissioning and abandonment probably would not result in the intensity of barge and truck movement as would be required for construction; however, impacts to transportation would be similar and minor.

7.7.3 Summary of Environmental Consequences

Equipment and materials transported through the Ports of Seward, Whittier, and Anchorage are expected to represent an increase of 1% to 26% over current levels. Incremental increases in truck traffic along the Dalton Highway would represent approximately 2% of existing levels. These are expected to represent minor impacts to transportation facilities. Barge and boat traffic associated with project construction, and bus and truck traffic for the transport of materials and workers, would increase traffic between Seal Island and West Dock, which would result in minor impacts to transportation facilities in the project area. Northstar crude oil would total approximately 4.3% of the TAPS throughput during peak project production years; the relative contribution of the project to TAPS would decline as production from the field declines. Contributions to the throughput of TAPS would be a beneficial impact. Construction-related impacts to transportation would be short-term; operations impacts to TAPS would be long-term over the 15-year life of the project.

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7.8 VISUAL/AESTHETIC CHARACTERISTICS

7.8.1 Affected Environment

Visual characteristics of the project area and concerns of area residents relative to viewshed, including landscape and atmospheric characteristics that could affect views of the project, are described in this chapter.

7.8.1.1 Physical Appearance

The Arctic Coastal Plain is a treeless, low-relief landscape dominated by numerous lakes and ponds and low-lying vegetation. The terrain is frozen and covered by ice and snow during the Arctic winter, which typically lasts more than 9 months with 56 days where the sun does not rise above the horizon. During the brief summer of continuous daylight (June through August), ponds, rivers, low-lying shrubs, wildflowers, birds, caribou, small mammals, and insects are noticeable features of the landscape (Strahler & Strahler, 1987:185). A low, grass-like sedge mat covers much of the area and red aquatic grass grows around ponds and lakes.

Cone-shaped hills and mounds (pingos) that reach elevations of more than 100 ft (31 m), are the only land-form on the coastal plain with any given height. Steep stream and river banks, coastal sand dune deposits, and steep coastal bluffs along the ocean create contrast in landscape elevation. Large rivers typically are braided and have broad floodplains and drainages. Smaller rivers and streams consist of thaw pools that are interconnected by narrow channels.

The nearshore area of the Alaskan Beaufort Sea is punctuated with barrier islands and changes considerably in appearance from winter to summer. Barrier islands (Section 5.3) are low elevation land masses, mostly of sand and gravel, with some low-lying tundra vegetation. During winter, the nearshore area freezes and snow and ice drift over the barrier islands, making it difficult to differentiate the shoreline from the sea ice. Although the ice is landfast north of the barrier islands, ice pressure ridges are common to heights over 13 ft (4 m) (Kovacs and Mellor, 1974:124). During the open water season, the ocean and floating ice provide visual contrast between the land and the edge of the ice pack. Seal and Cross Islands are 6 and 10 miles (9.6 and 16 km), respectively, from the shoreline, and can be seen from some onshore locations.

More than 10 onshore oil and gas fields with developed well and production facilities are located in the Prudhoe Bay area. Oil field facilities extend approximately 60 miles (96.5 km) along the coast and as much as 20 miles (32 km) inland. The facilities are characterized by gravel pads, reserve pits, large and small buildings, gravel roads, pipelines, snow fences, heavy equipment, drilling rigs, flares, lights, and powerlines. Manmade offshore structures include West Dock and Endicott causeways, which extend offshore for distances of more than 4 miles (6.4 km).

7.8.1.2 Atmospheric Conditions

Physical characteristics of the region combine to create several unique optical phenomena, including fata morganas (also referred to as loomings or mirages), light intensification, Arctic haze, and the Northern Lights (Aurora Borealis).

An almost continuous temperature inversion in the circumpolar Arctic results in abnormally refracted light which frequently results in fata morganas. As a result, distant objects and features are distorted and appear much larger or brighter than they actually are. Fata morganas are most noticeable when looking seaward during the open water season. Light intensification occurs when ice crystals are suspended in the air and cause a light source, such as a flare, to appear to be illuminated brightly. 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, which occurs mainly during winter and spring, can reduce visibility from 50 miles (80 km) to less than 5 miles (8 km). Although scientific research is ongoing, the predominant theory is that the haze originates from long-range transport of pollutants from industrialized Europe. Northern Lights occur frequently during winter in a variety of forms. Displays include a spectrum of colors including greens, pinks, and yellows, appearing as vertical moving streamers with luminous, expanding arcs, or fog-like glow.

7.8.1.3 Cultural Context

Nuiqsut and Kaktovik are the closest Native communities to the project. Nuiqsut is located on the Colville River, 18 miles (29 km) upriver from the Alaskan Beaufort Sea and approximately 60 miles (96.5 km) southwest of the project area. Kaktovik is located on the north shore of Barter Island, between the Okpilak and Jago Rivers on the Alaskan Beaufort Sea coast, approximately 150 miles (241 km) east of the project area. The project area, including Cross Island, is occasionally used by Nuiqsut residents during summer and fall for subsistence harvesting activities.

The Inupiat have expressed concerns about oil and gas development in the Prudhoe Bay area. Manmade color and lights are considered intrusive to the natural landscape, and some colors and bright lights are thought to affect marine mammals that are important to their subsistence lifestyle. Light from Prudhoe Bay oil field activities is sometimes visible as a distant glow from the community of Nuiqsut, serving as a constant reminder of oil and gas activity in the region. Additionally, oil and gas development is an indicator of visual change in the homogenous tundra environment and is considered as indicative of a change in the traditional subsistence way of life.

Public testimony received during scoping and other meetings held in North Slope communities indicates that people are concerned about industrialization and associated degradation of visual qualities of the area. The range of comments included visual impacts of dock facilities, degradation of rivers, and the creation of burning pits within the North Slope region. Concern also has been raised that additional oil and gas development projects will become widespread throughout the region and further reduce visual aesthetics of the area (Kruse et al., 1983:19; USACE, 1996:27).

7.8.2 Environmental Consequences

Visual impacts of the project are derived from the expected changes that would occur without the project and those that would occur from project construction, operation, maintenance, and abandonment. The level of impacts is variable and subjective, depending upon the duration and frequency of views, distance of the viewer, and viewer sensitivity. Although pipeline landfall locations differ among Alternatives 2, 3, 4, and 5, impacts to viewers and viewer sensitivity would be the same. Therefore, potential impacts for these alternatives are discussed together and are summarized in Table 7.8-1.

7.8.2.1 Alternative 1 - No Action Alternative

Although visual impacts from development and operation of the Northstar Unit would not occur if the project were not constructed, it is likely that visual qualities within the region would continue to change as a result of industrialization. The extent of change would depend upon the sequencing and scope of development; however, facilities lighting, air emissions, and processing and transportation facilities are likely to become more widespread throughout the area of oil and gas resource development in the North Slope region. Although Seal Island is only occasionally seen by whalers, without the project it would eventually erode to below sea level.

7.8.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Lighting from construction activities at the gravel mine, during trenching and pipe installation, and during island reconstruction is likely to appear to Nuiqsut residents as a faint glow on the horizon. During summer, viewers of the new onshore facilities would generally be limited to oil field workers who are accustomed to industrial activities and facilities of the Prudhoe Bay industrial area. View durations are likely to be limited to infrequent and/or short duration periods associated with travel to and from existing onshore facilities, which would result in minor visual impacts to oil field workers.

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Offshore reconstruction of Seal Island would not be visible from Nuiqsut due to distance (approximately 60 miles [96.5 km]) and the intervening Long Island landform. Calculations made to determine line of sight indicate the elevation of the flare tower (215 ft [65.5 m] above sea level) and of Nuiqsut (less than 50 ft [15.2 m] above sea level), would be less than that required for observation over the horizon. However, lights on elevated structures, including the Seal Island work surface, processor and compressor modules, flare tower, and worker quarters, are likely to be visible as a glow on the horizon. The intensity of the glow on the horizon would be increased under fata morgana and light intensification atmospheric conditions.

Air emissions from construction equipment and those from project operations are not expected to measurably increase atmospheric haze in the region. Air quality impacts are addressed in Section 5.4.

Operation, Maintenance, and Abandonment Impacts: The infrastructure on Seal Island would break horizontal views by introducing structures and an island base approximately 75 to 100 ft (23 to 30.5 m) above the water; the flare tower would rise approximately 215 ft (65.5 m) above sea level. However, due to its remote location, the facility would only be viewed by oil field workers and whaling crews during the fall subsistence hunt. To compensate for this visual distraction, Seal Island facilities would be painted a non-contrasting color and island piling, which would not be painted, would rust naturally. Impacts to oil field workers and subsistence hunters would be minor because the frequency and duration of views would be limited to workers within the industrial complex and the period when hunters are traveling between Nuiqsut and Cross Island.

The flare would be the highest point on Seal Island; however, it would have an open lattice support structure that would be difficult to detect visually. The flare would be used a maximum of 30 days per year. While flaring, the flame would be smokeless, virtually transparent, and light yellow and blue in color. A low pressure pilot, which would be smokeless and yellow to light orange in color, would operate continuously. Luminosity of the flare and the pilot is expected to be low because the flames would be virtually transparent.

The upper portion of the process module, compressor module, associated project lights, and flare would be visible from Cross Island (approximately 17 miles [27.3 km] from Seal Island). However, the structures would be painted in colors that would blend with the surrounding environment and would lack sharp contrast. The flare would be smokeless, virtually transparent, and light yellow to blue. Although the level of visual impacts associated with new facilities is dependent upon individual viewer sensitivity, impacts to whalers using Cross Island are expected to be minor, because the number of viewers would be relatively small and because the viewing period would generally be limited to a 2-week period during the fall whaling season. Onshore facilities and Seal Island would be visible to oil field workers; however, viewer duration is likely to be brief and the facilities would be similar to those currently in place in the area. Therefore, visual impacts to whalers on Cross Island and oil field workers are expected to be minor. As described previously, the project would be over the horizon and out of view from Nuiqsut. The glow of lights on the horizon would contribute to the existing glow produced from the Prudhoe Bay industrial complex that may be seen from the community during night/winter.

Concern has been expressed regarding the potential effects of light from the flare on the bowhead whale. Although information about such effects is not available, the flare will operate a maximum of 30 days per year with a nearly-transparent flame. Therefore, effects of the flare on the species are considered to be negligible. Information regarding the bowhead whale reaction to light and color and potential related effects on subsistence is provided in Section 7.3.

The shore approach for the pipeline would be visible from the sea, and onshore portions of Alternatives 2 and 3 would cross previously undisturbed tundra between the landfall and Pump Station No. 1. The onshore approach and valve station would be visible along the coast. Impacts to visual resources related to operation of the pipeline and ice road operations are expected to be limited primarily to oil field workers, regardless if viewed from the sea or land. Impacts to subsistence harvesters are expected to be minor because the area is seldom used by the Inupiat and because of the small number of viewers. There would be minor impacts to Nuiqsut residents due to a faint glow on the horizon.

There could be effects to the visual/aesthetic characteristics of the project area from an oil spill, and impacts are discussed in Chapter 8.

Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental affects of the abandonment alternatives. Abandonment activities would be similar in nature to construction activities and impacts would be minor. For an abandonment scenario involving complete removal of all facilities and infrastructure, the long-term impact would be expected to be beneficial. The removal of the facilities and infrastructure would eliminate the visual contrast and the glow produced by the lights and flare. In-place abandonment and/or reuse of a substantial portion of the project facilities would result in impacts that are similar to those generated during construction, and would be minor.

7.8.3 Summary of Environmental Consequences

Construction of the facility for Alternatives 2, 3, 4, and 5 would erect structures that would interrupt horizontal views. Construction of facilities on Seal Island and the onshore pipeline approach would be visible for the life of the project (15 years) and would affect the long-term visual resources if not dismantled during abandonment. The glow caused by the lighting and occasional use of the flare seen beyond the horizon from Nuiqsut would be visible for the life of the project, as well, but the long-term visual resources would return to pre-construction levels when the project is decommissioned. Due to the remote location and because the facilities would be viewed infrequently, visual impacts would be minor.

7.8.4 References

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7.9 RECREATION

7.9.1 Affected Environment

Recreational activities on the North Slope occur mostly in ANWR and the NPRA, and along the Dalton Highway, which provides the only road access to the North Slope. The area directly south of the project area is leased for oil and gas development and the only visitor recreation that occurs in the leased units is commercial tours of the Prudhoe Bay oil field. On rare occasions, a sea kayaker or boater may recreate in Prudhoe Bay or surrounding waters. The project area is located in the Alaskan Beaufort Sea and is utilized for subsistence activities (Section 7.3), but only rarely for recreational boating. The most likely recreational activities to be impacted by the project are those that occur along the Dalton Highway.

The U.S. Department of Interior Bureau of Land Management and the Alaska Department of Transportation and Public Facilities conducted a survey recently and ascertained that the most important reason visitors travel the Dalton Highway is to view scenery and wildlife (Robbe, 1996:18). Visitors on the Dalton Highway are most likely making a day trip from Fairbanks and back to experience crossing the Arctic Circle (Robbe, 1996:76). Recent studies have shown that an average of 269 vehicles per day travel the highway from April through September, of which 56 are traveling to engage in recreational activities (Robbe, 1996:70).

Recreational opportunities available along the Dalton Highway which may be impacted by the project include scenic viewing, camping, sportfishing, hiking, hunting, and recreational goldmining. Visitors travel the Dalton Highway to view wildlife such as moose, wolf, bear, caribou, Dall sheep, Arctic fox, red fox, wolverine, musk ox, smaller mammals, waterfowl, shorebirds, passerines, falcons, and golden eagles

(Jensen, 1994:52-53). The Arctic Circle Campground and Old Man Camp, located at the Arctic Circle stop of the Dalton Highway, are the only developed camping facilities along the Dalton Highway. An undeveloped Bureau of Land Management campground is located at Coldfoot. Tent or recreational vehicle camping typically occurs at informal camping sites along the length of the Dalton Highway in conjunction with fishing, hunting, and birding.

Sportfishing is allowed along the entire length of the Dalton Highway corridor. Grayling, Arctic char, lake trout, sheefish, and several varieties of whitefish are found in the region's waterways. Several hiking locations are popular along the Dalton Highway (Jensen, 1994:48-49). The Dalton Highway is used as a means of access to sport hunting opportunities on the North Slope. Game species include black and brown (grizzly) bear, caribou, moose, musk ox, Dall sheep, wolf, and waterfowl. Only bow hunting is allowed within 5 miles (8 km) of the Dalton Highway and the TAPS. Hunting with firearms is allowed outside the 5-mile (8 km) highway and pipeline corridor.

7.9.2 Environmental Consequences

Recreational activities likely to be impacted by the project are those that occur along the Dalton Highway. The construction phase of the project is the only time when impacts to recreational activities would be noticed, and impacts would be the same for Alternatives 2, 3, 4, and 5. Therefore, potential impacts for these alternatives are discussed together and are summarized in Table 7.9-1.

7.9.2.1 Alternative 1 - No Action Alternative

In 1996, the Alaska Superior Court ruled that the Dalton Highway be open to public access for the entire length of the roadway. Prior to this ruling, the highway was open the entire length only by permit. The

Table 7.9-1 (page 1 of 2)

Table 7.9-1 (page 2 of 2)

highway is expected to become an increasingly popular route to recreational activities on the North Slope, and travel along the highway is likely to increase. Commercial tours are expected to continue in the leased oil and gas units and kayakers or boaters will occasionally recreate in Prudhoe Bay and surrounding waters. These trends will continue regardless of project implementation.

7.9.2.2 Alternatives 2, 3, 4, and 5

Construction Impacts: Truck traffic on the Dalton Highway moving equipment, materials, and supplies would increase by two trucks per day during project construction. The Dalton Highway is a narrow (28 ft [8.5 m]) gravel road, and often other vehicles pull off the road when large trucks pass. The increased truck traffic could result in impacts to recreational activities along the transportation corridor and may reduce the recreational quality of the area. However, daily peak truck traffic is expected to increase less than 2% over current levels. This increased activity would begin prior to actual construction and continue over a 1-year period until the Northstar Unit becomes operational. Consequently, the increase in daily truck trips occurring during the project construction period would have a minor impact to recreational activities along the Dalton Highway.

Operation Impacts: Production operations and related activities on Seal Island are expected to be carried out continuously during the 15-year life of the project. Operation activities are expected to have no impact on recreational activities along the Dalton Highway. Truck traffic attributable to Northstar operations would be much less than during the construction phase.

An oil spill would have a negligible, indirect affect on recreational activity in the project area and along the Dalton Highway by potentially increasing traffic on the highway during spill response cleanup activities. Impacts to recreational activities from an oil spill are discussed in Chapter 8.

Maintenance Impacts: Maintenance activities are expected to require little or no additional truck traffic on the Dalton Highway and would, therefore, have no impact on recreational activities.

Abandonment Impacts: Abandonment impacts would depend upon the abandonment plan that is adopted, and will be fully addressed in the assessment of the environmental affects of the abandonment alternatives. For an abandonment scenario involving complete removal of all facilities and infrastructure, impacts to recreational activities would be expected to be similar to those generated during construction. Most likely, only recreational activities along the Dalton Highway would be impacted, and the overall impact of abandonment would be expected to be minor. For a scenario involving in-place abandonment and/or reuse of a substantial portion of the project facilities, the overall impacts of abandonment would be negligible.

7.9.3 Summary of Environmental Consequences

Impacts to recreation from Alternatives 2, 3, 4, and 5 would be limited to those along the Dalton Highway that would result from increased truck traffic. Truck traffic for the transport of construction equipment and materials would represent less than a 2% increase over present levels along the highway, and would continue over a 1-year period. This increase would create minor, short-term, indirect impacts to recreation activities along the highway as a result of additional truck traffic.

7.9.4 References

Jensen, Mike. Umbrella Guide to Alaska's Wilderness Highway. Seattle: Epicenter Press, 1994.

Robbe, Gregory A. 1995 Dalton Highway Visitor Survey Results Report. Prepared for the U.S. Bureau of Land Management and the Alaska Department of Transportation & Public Facilities by Gregory A. Robbe. Fairbanks: UAF, 1996.

7.10 ENVIRONMENTAL JUSTICE CONSIDERATIONS

Executive Order 12898 requires that federal agencies make achieving Environmental Justice part of their mission by identifying and addressing disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low income populations in the United States. Inupiat Eskimos, which are a minority population covered by Executive Order 12898, reside within the area which will likely be effected by the proposed Northstar development. Section 1.4.7 of Chapter 1 provides additional details on requirements related to Executive Order 12898 regarding Environmental Justice, and steps taken during the preparation of this EIS to meet those requirements.

In Section 7.3 Subsistence and 7.6 Socioeconomics of Chapter 7, potential effects resulting from Northstar development on North Slope Inupiat communities were identified. Given that North Slope Inupiat are a minority population covered by Executive Order 12898, the cooperating judicial agencies must determine whether these potential effects are disproportionately high as compared with effects on other, non-minority populations.

The conclusion of this EIS is that the potential effects of Northstar development on North Slope Inupiat are not, on balance, disproportionately high for the following reasons. The potential adverse effects described have a low likelihood of occurrence, have largely been mitigated by proposed project design and operations, and will be further mitigated by conditions on construction and operation activities placed by agencies on project authorizations. In addition, a primary goal of Executive Order 12898 is to avoid the selective imposition of effects of federal actions on populations which do not have the ability to prevent or oppose those actions. In this case, the interests of the North Slope residents have been represented by the NSB, a home rule municipal government with planning and zoning authority under which the project was comprehensively reviewed and approved. Further, the Arctic Slope Regional Corporation and Kuukpik Corporation which represent their Inupiat shareholders of the entire North Slope and Nuiqsut, respectively, have comprehensively reviewed the proposed project, and expressed their support for Northstar development. Finally, the cooperating federal agencies have recognized their responsibility under Executive Order 13084 to engage in consultation with potentially affected federally recognized tribal governments, and have taken steps through development of the EIS to ensure that North Slope tribal government officials were kept informed regarding the process and provided the opportunity to participate.

TABLE 7.3-1
SUBSISTENCE HARVESTS BY MAJOR RESOURCE CATEGORY

Harvest	Resource					
	Marine Mammals	Terrestrial Mammals	Fish	Birds	Other Resources	Total
Barrow [1, 2, 3]						
Annual Usable Pounds Harvested	386,153	211,861	79,355	24,720	572	702,660
Percent of Households Harvesting Resources	48	54	41	53	7	68
Nuiqsut [3, 4]						
Annual Usable Pounds Harvested	85,216	87,390	90,490	4,325	396	267,818
Percent of Households Harvesting Resources	37	76	81	76	61	90
Kaktovik [3, 5]						
Annual Usable Pounds Harvested	115,645	28,867	22,952	3,249	227	170,940
Percent of Households Harvesting Resources	40	68	81	64	32	89

Notes: 1 = Three years of study: April 1, 1987 - March 31, 1990. Percentage of households harvesting is a cumulative total for the three study years rather than an annual average.

Sources:
2 = SRB&A and ISER, 1993:64
3 = Braund, 1997:54, 82, and 100
4 = Pedersen, 1995b:XXII-28-30
5 = Based on a 1992/1993 study - Pedersen, 1995a:XXI-22-24

TABLE 7.3-2
DOCUMENTED ANNUAL LANDED BOWHEAD WHALES
1964 - 1995

Year	Barrow	Nuiqsut [1]	Kaktovik	Year	Barrow	Nuiqsut	Kaktovik
1964	11	--	2	1980	9	0	1
1965	4	--	0	1981	4	0	3
1966	7	--	0	1982	0	1	1
1967	3	--	1	1983	2	0	1
1968	10	--	0	1984	4	0	1
1969	11	--	0	1985	5	0	0
1970	16	--	0	1986	8	1	3
1971	12	--	0	1987	7	1	0
1972	20	--	1	1988	11	0	1
1973	17	1	3	1989	10	2	3
1974	9	0	2	1990	11	0	2
1975	10	0	0	1991	13	1	0
1976	23	0	2	1992	22	2	3
1977	20	0	2	1993	23	3	3
1978	4	0	2	1994	16	0	3
1979	3	0	5	1995	21	4	4

Notes: 1 = The community of Nuiqsut was not re-settled until 1973.
-- = Not Applicable

Source: Braund, 1997:35, 36

TABLE 7.3-3
BOWHEAD WHALE QUOTA AND HARVEST, 1978-1991[1]

Year	Quota (struck/landed)	Landed	Struck-but-lost	Total Strikes
1978	20/14	12	6	18
1979	27/18	12	15	27
1980	26/18	16	28	44
1981	65/45 No more than 17 landed per year	17	11	28
1982		8	11	19
1983		9	9	18
1984	43 strikes No more than 27 landed per year	12	13	25
1985		11	6	17
1986	32 strikes	20	8	28
1987	32 strikes	22	9	31
1988	35 strikes	23	6	29
1989	44/41 per year, 3 strike carry over per year	18	8	26
1990		30	14	44
1991		28	19	47

Note: 1 = For the nine communities which engaged in subsistence bowhead whaling prior to 1995 and ten communities after 1995 with the inclusion of Little Diomede.

Source: Braund and Moorehead, 1995:257-258; Suydam et al., 1995:336.

TABLE 7.3-4
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SUBSISTENCE RESOURCES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	N/A	None - Ice roads would not remain to impede fall whale migration or subsistence harvesting.	None anticipated.
Ice Roads – Operations	Annually	All winter	N/A	None - Ice roads would not remain to impede fall whale migration or subsistence harvesting.	None anticipated.
Island – Construction	Once	3 Months	Western part of Nuiqsut whaling area between Cross Island and Seal Island, approximately 300 square miles (777 km^2).	Minor - To bowhead whaling if impacts were only from small boat operations; migration pattern would be deflected no more than 6 mi (9.7 km), which would have little effect on whaling from the Cross Island harvest area. Significant - To Nuiqsut's bowhead whale harvest. Possible deflection of whales of up to 25 miles (40 km) due to noise from construction activities and vessel traffic occurring during fall migration could result in a reduction in bowheads being harvested. Additional travel could result in meat spoilage and increased risk to hunters. An increase in unsuccessful whale strikes due to project-related disturbance could have an adverse effect on IWC whale harvest quotas.	A significant reduction or elimination of bowheads being harvested during an annual hunting season would have a significant but short-term sociocultural impact, resulting in the unavailability of food of great cultural importance to the Inupiat. There would be related impacts on the sharing of culturally important foods and cultural events associated with the harvest of bowhead whales.
Island – Operation/ Maintenance	Annually	15 years	Western part of Nuiqsut whaling area between Cross Island and Seal Island, approximately 300 square miles (777 km^2).	Minor - To bowhead harvest if long-term displacement from operations/maintenance noise did not occur. Significant - To Nuiqsut's bowhead harvest if long-term displacement of migrating whales due to noise from island slope maintenance and boat and helicopter activities were to occur during fall migration. Additional travel could result in meat spoilage and increased risk to hunters. An increase in unsuccessful whale strikes due to project-related disturbance could have an adverse effect on IWC whale harvest quotas. Displacement distance of whales due to colors, flares, and facility lighting is unknown, but may occur.	A significant reduction or elimination of bowheads being harvested during an annual hunting season would have a significant but short-term sociocultural impact, resulting in the unavailability of food of great cultural importance to the Inupiat. There would be related impacts on the sharing of culturally important foods and cultural events associated with the harvest of bowhead whales.

TABLE 7.3-4 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SUBSISTENCE RESOURCES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Offshore Pipeline – Construction	Once	3 Months (Winter)	N/A	None - Winter construction would not affect subsistence harvesting.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	N/A	None - No additional noise or vessel traffic related to offshore pipeline operation and routine maintenance.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	N/A	None - Onshore pipeline construction would take place in the winter; caribou calving and migration would not be affected; caribou are not expected to be impacted by helicopter traffic.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None – The pipeline would not restrict caribou migration and availability of caribou for subsistence harvest would not be impacted; caribou are not expected to be impacted by helicopter traffic.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None - Onshore gravel mining would take place in the winter and would not affect subsistence harvesting.	None anticipated.
Large Oil Spill	Rare	Unknown	Barrow, Nuiqsut, and Kaktovik hunting and fishing areas contacted by an oil spill.	Minor - An onshore oil spill could reduce subsistence harvesting in hunting and fishing areas near the project area. Significant - An offshore oil spill and spill response activities could cause partial or complete suspension of subsistence harvesting due to destruction of habitat or displacement of marine mammals, fish, and waterfowl.	Minor – Localized disturbance from icebreaking barge activities during broken/thin ice conditions may occur even though an oil spill has not. Significant - Reduced or discontinued use of subsistence resources for years after a spill due to fears of resource contamination. Any effect on the bowhead whale population or reduction in hunting success could be reflected in reduced IWC harvest quotas for bowheads.

TABLE 7.3-4 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SUBSISTENCE RESOURCES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Abandonment	Once	3 to 6 Months	Western part of Nuiqsut whaling area between Cross Island and Seal Island, approximately 300 square miles (777 km^2).	Beneficial - To Nuiqsut hunters due to the possible reuse of the project facilities during severe weather while traveling to Cross Island. Significant - To Nuiqsut's bowhead whale harvest from possible deflection of whales due to noise from abandonment activities. Type and level of noise generated and the deflection of whales is unknown. If activities occurred during fall migration, bowhead harvest could be unsuccessful.	A significant reduction or elimination of bowheads being harvested during an annual hunting season would have a significant but short term sociocultural impact, resulting in the unavailability of food of great cultural importance to the Inupiat. There would be related impacts on the sharing of culturally important foods and cultural events associated with the harvest of bowhead whales.

Notes:
IWC = International Whaling Commission
km = Kilometers
km^2 = Square kilometers
N/A = Not applicable

TABLE 7.4-1
CULTURAL/ARCHAEOLOGICAL RESOURCES NEAR THE PROJECT AREA

Site	Vicinity of	Resource
HAR-001	Thetis Island	Prehistoric houses, artifacts; by 1979, site most likely destroyed by a storm
XBP-002	Anxiety Point	Hunting camp
XBP-003	Beechey Point	Ahvakana home
XBP-004	Kavearak Point	Sod houses
XBP-005	Prudhoe Bay	Semi-subterranean houses and driftwood cabin
XBP-006	Heald Point	Site destroyed by Niakuk oil field development
XBP-007	Prudhoe Bay	Fire hearths and lithic scatters from the Arctic Small Tool, Archaic, and Paleoarctic Traditions
XBP-008	Central Creek Pingo	Artifacts from the Arctic Small Tool Tradition
XBP-009	Cross Island	Cabins, house depressions, present whaling camp
XBP-010	Milne Point	Sod houses and other structures
XBP-011	Pingok Island	Naval Arctic Research Laboratory station
XBP-012	Pingok Island	Old village dating from A.D. 1500
XBP-013	Peet Island	Sod houses; by 1983, site almost entirely destroyed by natural forces
XBP-014	Cottle Island	Driftwood structures; whalebone
XBP-015	Back Point	Sod houses; scattered graves
XBP-016	Gwydyr Bay	Historic house ruin
XBP-017	Kuparuk River	Sod houses
XBP-018	Long Island	Whaling boat
XBP-019	Point McIntyre	Sod houses
XBP-020	Sagavanirktok River	Sod/wooden house
XBP-021	Sagavanirktok River	Small boat
XBP-030	Pingok Island	Grave site
XBP-034	Pingok Island	Historic or prehistoric houses
XBP-035	Spy Islands	Sod houses and graves
XBP-038	Ugnuravik Pingo	Prehistoric and historic artifacts
XBP-040	Point Storkerson	DEW Line station
XBP-043	Beechey Point	Artifacts from the Arctic Small Tool Tradition
XBP-045	East Creek Pingo	Artifacts from short-term camp

TABLE 7.4-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON CULTURAL/ARCHAEOLOGICAL RESOURCES

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	No known resources in area.	None anticipated.	None anticipated.
Ice Roads - Operations	Annually	All winter	No known resources in area.	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	No known resources in area.	Minor – To potential offshore cultural resources.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	No known resources in area.	None anticipated.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	No known resources in area.	Minor – To potential offshore cultural resources.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	No known resources in area.	None anticipated.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	DEW Line Site Sod House Ruins Putuligayuk River Delta Overlook Site	None - Pipeline construction would avoid known cultural resource sites.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	DEW Line Site Sod House Ruins Putuligayuk River Delta Overlook Site	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	No known resources in area.	None anticipated.	None anticipated.
Large Oil Spill	Rare	Unknown	Any of the identified sites or unknown cultural resources in the area that are contacted by oil.	Significant - Irreparable damage to historic artifacts and interference with radiocarbon dating tests from contact with spilled oil.	Significant - Onshore spill response activities could damage integrity of coastal and onshore sites.
Abandonment	Once	3 to 6 Months	No known resources in area.	None anticipated.	None anticipated.

Notes: DEW = Distant Early Warning km = Kilometers

TABLE 7.5-1
NORTH SLOPE BOROUGH LAND MANAGEMENT REGULATIONS

NSB Municipal Code	Summary of Policy	Application to Project
19.70.040 (E)	"All nonessential boat, barge and air traffic associated with drilling activity shall occur prior to or after the period of whale migration through the area. Essential traffic (traffic that could not reasonably occur prior to or after the period of whale migration) shall avoid disrupting the whale migration, subsistence activities and be coordinated with the Alaska Eskimo Whaling Commission."	Compliance with the obligations in this policy likely will be through the development of the Master Plan for rezoning.
19.70.050 (A)	Drilling would be conducted from bottom-founded structures. NSBMC 19.20.020 (9) defines the term "bottom-founded structures" as including "gravel and grounded ice islands, single steel drilling caissons (SSDC), concrete island drilling systems (CIDS), and other offshore drilling platforms which rest on and are supported by the ocean floor, and have primary blowout preventors above the surface of the water."	The project will be drilled from an artificial island that satisfies requirements for a bottom-founded structure under the first section of this policy.
19.70.050 (B)	Drilling above threshold depth may occur year-round. The policy affirms that drilling may take place above the threshold depth at any time. "Threshold depth" is defined in NSBMC Section 19.20.020 (66) as "the depth below surface as such a significant accumulation of oil and gas can reasonably be expected to be encountered while drilling the well."	The proposed drilling program will be in compliance with this policy.
19.70.050 (C)	Drilling below threshold depth in the Beaufort Sea shall be conducted during winter (November 1 through April 15) and be completed as early as possible.	The project may conflict with compliance unless the policy is eliminated or modified through the Master Plan process.
19.70.050 (D)	Confirmation, extension drilling, well testing, and other well completion activities in the Beaufort Sea shall be completed by June 15. Consistent with NSBMC 19.70.050 (C), any additional drilling or other activities would not penetrate any new oil or gas bearing formation, or significantly increase the risk of an oil spill.	The project may conflict with compliance with this policy unless the policy is eliminated or modified through the Master Plan process.
19.70.050 (F)	Year-round drilling can occur following the unitization and approval of the Plan of Operations, NSB approval of a Master Plan, and rezoning to the Resource Development District for the proposed development.	This policy, in combination with the previous policies on drilling, indicates that in order to allow drilling outside of the November 1 through April 15 window, the area will have to be rezoned from a Conservation District to Resource Development District.
19.70.050 I.2	Similar to NSB CMP policy 2.4.4 (b), this policy requires "offshore structures must be able to withstand geophysical hazards and forces which may occur at the drill site," and that structures 'must have monitoring programs and safety systems capable of securing wells in case unexpected geophysical hazards or forces are encountered.'	Residents of Nuiqsut have expressed concern based on Traditional Knowledge whether the facility on Seal Island can withstand sea ice hazards and forces that may occur at the site. Compliance with this policy will be determined during state consistency review and development of the Master Plan for rezoning.

TABLE 7.5-1 (Cont.)
NORTH SLOPE BOROUGH LAND MANAGEMENT REGULATIONS

NSB Municipal Code	Summary of Policy	Application to Project
1970.050 I.7	Similar to NSB CMP policy 2.4.4 (g), this policy requires “offshore drilling activities, offshore petroleum storage, and transportation facilities...to have an oil spill control and clean-up plan.”	Residents of Nuiqsut have expressed concern based on Traditional Knowledge whether spilled oil cannot be detected or recovered under certain types of sea ice. Compliance with this policy likely will be through state and federal approval of the ODPCP, and during state consistency review.
19.70.050 I.8	Similar to NSB CMP policy 2.4.4 (h), this policy requires “offshore oil transport systems (including pipelines) must be specifically designed to withstand geophysical hazards, specifically sea ice.”	Residents of Nuiqsut have expressed concern based on Traditional Knowledge whether the facility on Seal Island can withstand sea ice hazards and forces that may occur at the site. Compliance with this policy will be determined during state consistency review and development of the Master Plan for rezoning.
19.70.050 (d)	Similar to NSB CMP policy 2.4.3 (d), it requires “development not preclude reasonable subsistence user access to a subsistence resource.”	Compliance with obligations in this policy likely will be through development of the Master Plan for rezoning.
19.70.050 J.2	Similar to NSB CMP policy 2.4.5.1 (b), it requires “development that restricts subsistence user access to a resource meet three criteria”: 1) that there is a significant public need associated with the proposed activity; 2) that all feasible and prudent alternatives have been rigorously explored and objectively evaluated, and cannot comply with the policy; and 3) that all feasible and prudent steps have been taken to avoid any adverse effect that the policy was intended to prevent.	Compliance with obligations in this policy likely will be through development of the Master Plan for rezoning.
19.70.050 (a)	Similar to NSB CMP policy 2.4.3 (a), this policy addresses “extensive adverse impacts to a subsistence resource that are likely and cannot be avoided or mitigated...development shall not deplete subsistence resources below the subsistence needs of local residents of the Borough.”	Compliance with obligations in this policy likely will be through development of the Master Plan for rezoning.
19.70.050 I.1	Similar to NSB CMP policy 2.4.4 (a), it requires “vehicles, vessels, and aircraft that are likely to cause significant disturbance must avoid areas where species that are sensitive to noise or movement are concentrated when such species are concentrated.”	Compliance with obligations in this policy likely will be through development of the Master Plan for rezoning.
19.70.050 J.1	Similar to NSB CMP policy 2.4.5.1 (a), this policy addresses “development that will likely result in significantly decreased productivity of subsistence resources and their ecosystems.”	Compliance with obligations in this policy likely will be through development of the Master Plan for rezoning.

Notes: CMP = Coastal Management Program
NSB = North Slope Borough
NSBMC = North Slope Borough Municipal Code

TABLE 7.5-2
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON LAND AND WATER USE

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	N/A	None anticipated.	None anticipated.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Northstar Unit - Offshore marine waters	Negligible - To traditional water use boat traffic access due to vessel traffic associated with construction activities. Rezoning of the unit from Conservation District to Resource Development District will be required prior to project construction.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Northstar Unit - Offshore marine waters	Negligible - To traditional water use boat traffic access due to potential conflicts between barges and work boats and whaling vessels.	None anticipated.
Offshore Pipeline - Construction	Once	3 Months (Winter)	N/A	None anticipated.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	N/A	None anticipated.	None anticipated.
Onshore Pipeline - Construction	Once	6 Months (Winter)	Onshore pipeline route	Negligible - To traditional land uses due to encroachment of project facilities on Native Allotments; to traditional use offshore boat access from operations boat traffic. Minor - To onshore transportation, pipeline, and utility uses as a result of pipeline construction across existing right-of-ways and facilities; zoning would be changed from Conservation District to Resource Development District. Minor – Alternative 2 and a portion of Alternative 3 would add a pipeline across a currently undeveloped area. Minor – Alternative 5 may require an agreement among the owners if need to widen West Dock causeway. Minor – Alternatives 3, 4, and 5 could disrupt access, utility services, and existing pipeline operations in the areas near West Dock and CCP. Offshore zoning would be changed from Conservation to Resource Development District.	None anticipated.

TABLE 7.5-2 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON LAND AND WATER USE

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	N/A	None anticipated.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None anticipated.	None anticipated.
Large Oil Spill	Rare	Unknown	Marine waters, shorelines, or tundra contacted by oil - up to hundreds of miles from the release site.	Negligible – Change in land use due to disturbance or damage to tundra, vegetation, or surface water bodies as a result of contamination.	Negligible – Restricted access to areas for other activities during spill responses and cleanup mobilization during the summer.
Abandonment	Once	3 to 6 Months	Northstar Unit	Minor - Rezoning may be required following removal of onshore and offshore facilities. Some areas may revert to land uses in place prior to project construction.	None anticipated.

Notes: CCP = Central Compressor Plant
N/A = Not applicable

TABLE 7.6-1
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SOCIOECONOMICS

Action/Event	Frequency	Duration	Scope	Direct Impacts [1, 2]	Indirect Impacts
Ice Roads – Construction	Once	All winter	State of Alaska; NSB	Beneficial - Total project construction revenues estimated at $478.6 and $306.3 million in state and federal, respectively, taxes and royalties, and $64.3 and $3 million in NSB and MOA, respectively, taxes and royalties; 730 Alaska construction jobs ($51.6 million in wages). Negligible - Temporary increase in population in Anchorage and Fairbanks due to construction jobs.	Expect at least a one-to-one correlation of direct and indirect man-hours.
Ice Roads - Operations	Annually	All winter	State of Alaska; NSB	Beneficial – 100 annual Alaska operation jobs ($255 million in total wages).	Expect at least a one-to-one correlation of direct and indirect man-hours.
Island - Construction	Once	3 Months	State of Alaska; NSB	Beneficial - Total project construction revenues estimated at $478.6 and $306.3 million in state and federal, respectively, taxes and royalties, and $64.3 and $3 million in NSB and MOA, respectively, taxes and royalties; 730 Alaska construction jobs ($51.6 million in wages). Negligible – Temporary increase in population in Anchorage and Fairbanks due to construction jobs.	Expect at least a one-to-one correlation of direct and indirect man-hours
Island - Operation/ Maintenance	Annually	15 years	State of Alaska; NSB	Beneficial – 100 annual Alaska operation jobs ($255 million in total wages).	Expect at least a one-to-one correlation of direct and indirect man-hours.
Offshore Pipeline – Construction	Once	3 Months (Winter)	State of Alaska; NSB	Beneficial – Total project construction revenues estimated at $478.6 and $306.3 million in state and federal, respectively, taxes and royalties, and $64.3 and $3 million in NSB and MOA, respectively, taxes and royalties; 730 Alaska construction jobs ($51.6 million in wages). Negligible – Temporary increase in population in Anchorage and Fairbanks due to construction jobs.	Expect at least a one-to-one correlation of direct and indirect man-hours.

TABLE 7.6-1 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SOCIOECONOMICS

Action/Event	Frequency	Duration	Scope	Direct Impacts [1, 2]	Indirect Impacts
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	State of Alaska; NSB	Beneficial – 100 annual Alaska operation jobs ($255 million in total wages).	Expect at least a one-to-one correlation of direct and indirect man-hours.
Onshore Pipeline – Construction	Once	6 Months (Winter)	State of Alaska; NSB	Beneficial – Total project construction revenues estimated at $478.6 and $306.3 million in state and federal, respectively, taxes and royalties, and $64.3 and $3 million in NSB and MOA, respectively, taxes and royalties; 730 Alaska construction jobs ($51.6 million in wages). Negligible – Temporary increase in population in Anchorage and Fairbanks due to construction jobs.	Expect at least a one-to-one correlation of direct and indirect man-hours.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	State of Alaska; NSB	Beneficial – 100 annual Alaska operation jobs ($255 million in total wages).	Expect at least a one-to-one correlation of direct and indirect man-hours.
Gravel Mining Construction Operation	 Once Occasionall y	 3 Months (Winter) Unknown	State of Alaska; NSB	Beneficial - Total project construction revenues estimated at $478.6 and $306.3 million in state and federal, respectively, taxes and royalties, and $64.3 and $3 million in NSB and MOA, respectively, taxes and royalties; 730 Alaska construction jobs ($51.6 million in wages). Negligible - Temporary increase in population in Anchorage and Fairbanks due to construction jobs.	Expect at least a one-to-one correlation of direct and indirect man-hours.
Large Oil Spill	Rare	Unknown	State of Alaska, NSB, Anchorage, Fairbanks	Significant - Loss of revenues and increased costs; sudden increase in high wage paying jobs and subsequent inflation due to hiring of local labor for cleanup operations; reduced access to community services due to rapid expansion of workforce needed for cleanup operations.	None anticipate.

TABLE 7.6-1 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON SOCIOECONOMICS

Action/Event	Frequency	Duration	Scope	Direct Impacts [1, 2]	Indirect Impacts
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method.	Negligible Beneficial – From in place abandonment and/or reuse of a substantial portion of the facilities. Minor Beneficial – From removal of the facilities and infrastructure.	Expect at least a one-to-one correlation of direct and indirect man-hours.

Notes: 1 = Construction impacts (jobs and wages) reflect totals for the project, including: ice road construction, island construction, onshore and offshore pipeline construction, and gravel mining.

2 = Operation impacts (jobs and wages) reflect totals for the project, including: island operation/maintenance and onshore pipeline operation/maintenance.

MOA = Municipality of Anchorage

NSB = North Slope Borough

TABLE 7.6-2
STATE AND FEDERAL REVENUES FROM THE NORTHSTAR PROJECT AT 158 MILLION BARRELS

Component	2000	2001	2002	2003	2004	2005
Oil Production Rate (thousands of barrels per day)	32,065	65,000	65,000	65,000	61,935	43,700
ANS Market Price for Oil ($/Barrel)	$13.27	$15.90	$16.23	$16.66	$17.13	$17.61
ANS Wellhead ($/Barrel)	$9.07	$11.49	$11.74	$12.10	$12.52	$12.27
Gross Revenues	**$106,152,786**	**$272,600,250**	**$278,531,500**	**$287,072,500**	**$283,030,563**	**$195,712,635**
State Revenues						
State Royalty	$17,108,777	$43,935,324	$44,891,271	$46,267,834	$45,616,390	$31,543,250
State Supplemental Royalty	$2,472,753	$6,350,027	$6,488,191	$6,687,148	$6,592,994	$4,558,985
Net Profit Share Lease	$0	$0	$0	$0	$0	$0
State Share of Federal Royalty	$1,069,299	$2,745,958	$2,805,704	$2,891,740	$2,851,024	$1,971,453
Severance Tax	$3,876,207	$9,954,097	$10,170,678	$10,482,556	$10,334,963	$7,146,518
Spill & Conservation Tax	$200,493	$514,867	$526,070	$542,201	$534,567	$369,647
Ad Valorem Tax	$515,250	$491,308	$467,366	$443,424	$419,482	$395,540
Income Tax	$1,603,948	$4,118,937	$4,208,557	$4,337,609	$4,276,537	$2,957,180
Total State Revenues	**$26,846,728**	**$68,110,517**	**$69,557,837**	**$71,652,513**	**$70,625,957**	**$48,942,574**
Federal Revenues						
Royalty (net of state share)	$2,940,432	$7,551,027	$7,715,323	$7,951,908	$7,839,947	$5,421,240
Income Tax	$14,373,087	$36,910,074	$37,713,165	$38,869,617	$38,322,338	$26,499,491
Total Federal Revenues	**$17,313,519**	**$44,461,101**	**$45,428,488**	**$46,821,525**	**$46,162,285**	**$31,920,731**

TABLE 7.6-2 (Cont.)
STATE AND FEDERAL REVENUES FROM THE NORTHSTAR PROJECT AT 158 MILLION BARRELS

Component	2006	2007	2008	2009	2010	2011
Oil Production Rate (thousands of barrels per day)	30,834	21,755	15,350	10,831	7,642	5,392
ANS Market Price for Oil ($/Barrel)	$18.10	$18.62	$19.16	$19.72	$20.31	$20.91
ANS Wellhead ($/Barrel)	$12.61	$13.00	$13.36	$13.76	$13.58	$13.94
Gross Revenues	**$141,918,110**	**$103,227,475**	**$74,852,740**	**$54,397,614**	**$37,879,101**	**$27,435,035**
State Revenues						
State Royalty	$22,873,119	$16,637,301	$12,064,110	$8,767,332	$6,105,022	$4,421,739
State Supplemental Royalty	$3,305,881	$2,404,610	$1,743,641	$1,267,153	$882,366	$639,079
Net Profit Share Lease	$0	$0	$0	$0	$0	$0
State Share of Federal Royalty	$1,429,570	$1,039,831	$754,007	$547,958	$381,564	$276,359
Severance Tax	$5,182,191	$3,769,389	$2,733,275	$1,986,349	$1,383,169	$1,001,800
Spill & Conservation Tax	$268,044	$194,968	$141,376	$102,742	$71,543	$51,817
Ad Valorem Tax	$371,598	$347,656	$323,714	$299,772	$275,830	$251,889
Income Tax	$2,144,355	$1,559,747	$1,131,010	$821,937	$572,346	$414,538
Total State Revenues	**$35,574,758**	**$25,953,503**	**$18,891,133**	**$13,793,243**	**$9,671,841**	**$7,057,222**
Federal Revenues						
Royality (net of state share)	$3,931,132	$2,859,401	$2,073,421	$1,506,814	$1,049,251	$759,950
Income Tax	$19,215,712	$13,977,000	$10,135,061	$7,365,437	$5,128,830	$3,714,704
Total Federal Revenues	**$23,146,844**	**$16,836,401**	**$12,208,482**	**$8,872,251**	**$6,178,081**	**$4,474,654**

TABLE 7.6-2 (Cont.)
STATE AND FEDERAL REVENUES FROM THE NORTHSTAR PROJECT AT 158 MILLION BARRELS

Component	2012	2013	2014	Total
Oil Production Rate (thousands of barrels per day)	3,804	2,684	1,894	**158,003,390**
ANS Market Price for Oil ($/Barrel)	$21.52	$22.15	$22.80	**N/A**
ANS Wellhead ($/Barrel)	$14.61	$14.96	$15.31	**N/A**
Gross Revenues	**$20,285,401**	**$14,655,714**	**$10,583,956**	**$1,908,335,380**
State Revenues				
State Royalty	$3,269,423	$2,362,080	$1,705,829	**$307,568,802**
State Supplemental Royalty	$472,534	$341,394	$246,546	**$44,453,303**
Net Profit Share Lease	$0	$0	$0	**$0**
State Share of Federal Royalty	$204,339	$147,630	$106,614	**$19,223,050**
Severance Tax	$740,729	$535,159	$386,477	**$69,683,557**
Spill & Conservation Tax	$38,314	$27,681	$19,990	**$3,604,322**
Ad Valorem Tax	$227,947	$204,005	$180,063	**$5,214,844**
Income Tax	$306,508	$221,445	$159,922	**$28,834,575**
Total State Revenues	**$5,259,794**	**$3,839,393**	**$2,805,441**	**$478,582,453**
Federal Revenues				
Royality (net of state share)	$561,906	$405,963	$293,176	**$52,860,890**
Income Tax	$561,906	$405,963	$293,176	**$253,485,560**
Total Federal Revenues	**$1,123,811**	**$811,927**	**$586,351**	**$306,346,450**

Notes: Methodology: State and federal revenues for 158 million barrels of total production were estimated using ratios calculated from the model published by the ADNR Oil & Gas Division 1996 Northstar Economic Evaluation. Gross revenue was estimated using a total production of 158 million barrels and the Fall 1998 Base Price Forecast for ANS Wellhead oil prices for the period 2000 to 2014. Ad Valorem tax was estimated from data provided by Hanley, 1997a.

ADNR = Alaska Department of Natural Resources
ANS = Alaska North Slope
N/A = Not applicable

Source: Dames & Moore production scenario for 158 million barrels production, November 1998

TABLE 7.6-3
PROJECTED ESTIMATED ALASKA EMPLOYMENT

Material/Service	Average No. of Personnel	Estimated Duration (months)	Primary Contractor	Location of Workforce	Estimated Direct Man-hours	Estimated Wages (total $)
Construction						
Engineering	40	8	Veco/PN&D	Anc/NS	70,000	$2,228,800
Anc Fabrication	250	17	Veco/APC	Anc	900,000	$18,912,600
NS Island Construction	60	10	AIC	NS	180,000	$3,782,520
NS Pipeline Construction	200	6	HCC/AIC	NS	360,000	$7,565,040
NS Facilities Installation	90	4	Veco	NS	110,000	$2,224,420
NS Drilling	50	21	Nabors	NS	320,000	$8,896,000
BPXA Directs	40	27	N/A	Anc	200,000	$7,984,000
Subtotal	730	N/A	N/A	N/A	2,140,000	$51,594,380
Operation						
BPXA Operation	100	180	N/A	NS	N/A	$255,000,000
TOTAL	**830**	**N/A**	**N/A**	**N/A**	**N/A**	**$306,594,380**

Notes:
- AIC = Alaska Interstate Construction
- Anc = Anchorage
- APC = Alaska Petroleum Contractors
- BPXA = BP Exploration (Alaska) Inc.
- HCC = Houston Contracting Co.
- N/A = Not applicable
- Nabors = Nabors Alaska Drilling
- NS = North Slope
- PN&D = PN&D, Inc. Engineering Consultants
- Veco = Veco Operations Inc.

Source: BPXA, 1997:Table 1.2-4; Hanley, 1997b

TABLE 7.7-1
NUMBER OF SEALIFT BARGES, 1968-1996

Year	Number Barges	Year	Number Barges
1975	47	1986	27
1976	21	1987	6
1977	7	1988	0
1978	10	1989	3
1979	2	1990	3
1980	10	1991	1
1981	14	1992	0
1982	15	1993	3
1983	26	1994	4
1984	11	1995	0
1985	13	1996	0

Source: Toruga - Pers. Comm., 1996

TABLE 7.7-2
ANNUAL AVERAGE DAILY TRAFFIC ALONG THE DALTON HIGHWAY[1]

Highway Section	Number of Vehicles			
	1992	**1993**	**1994**	**1995**
Yukon Crossing (Milepost 55.6)	225	200	200	269
Bonanza Creek (Milepost 124.7)	N/A	N/A	N/A	154
Dietrich Camp (Milepost 209.1)	N/A	N/A	N/A	147
Kuparuk River (Milepost 288.8)	100	100	100	143

Notes: 1 = During visitor traffic season
N/A = Not applicable

Source: Robbe, 1996:70

TABLE 7.7-3
IMPACTS OF ALTERNATIVES 2, 3, 4, and 5 ON TRANSPORTATION

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads - Construction	Once	All winter	N/A	None anticipated.	None anticipated.
Ice Roads - Operations	Annually	All winter	N/A	None anticipated.	None anticipated.
Island - Construction	Once	3 Months	Freight through Ports of Anchorage, Whittier, and Seward; traffic along the Dalton Highway; passengers through Anchorage, Fairbanks, and Deadhorse airports; personnel and materials by helicopter, boat, barge, and bus in the Prudhoe Bay area; module barges from Anchorage.	Minor - From overall project construction activities to ports resulting from 1% to 26% increase in freight traffic; <2% increase in freight traffic along the Dalton Highway; <4% increase in passenger traffic through Anchorage, Fairbanks, and Deadhorse airports; module barges from Anchorage.	None anticipated.
Island - Operation/ Maintenance	Annually	15 years	Freight levels at Ports of Anchorage, Whittier, and Seward; traffic on the Dalton Highway; passengers by air; personnel and materials by helicopter, boat, barge, and bus in the Prudhoe Bay area.	Negligible – Increase (over current levels) in freight traffic at ports and along the Dalton Highway; increase (over current levels) in passenger and freight traffic through Anchorage, Fairbanks, and Deadhorse airports; increase in local helicopter, barge, boat, and bus passenger and freight traffic within the Prudhoe Bay area.	Beneficial impact associated with production of crude oil volumes representing approximately 4% of Trans Alaska Pipeline System throughput.
Offshore Pipeline - Construction	Once	3 Months (Winter)	Freight through Ports of Anchorage, Whittier, and Seward; traffic along the Dalton Highway; passengers through Anchorage, Fairbanks, and Deadhorse airports.	Minor – From overall project construction activities to Ports resulting from 1% to 26% increase in freight traffic; <2% increase in freight traffic along the Dalton Highway; and <4% increase in passenger and freight traffic through Anchorage, Fairbanks, and Deadhorse airports.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Local transportation of personnel and materials within the Prudhoe Bay industrial complex.	Negligible – Increase (over current levels) in freight traffic at ports and along the Dalton Highway; increase (over current levels) in passenger and freight traffic through Anchorage, Fairbanks, and Deadhorse airports; increase local helicopter, barge, boat, and bus passenger and freight traffic within the Prudhoe Bay area.	None anticipated.

TABLE 7.7-3 (Cont.)

IMPACTS OF ALTERNATIVES 2, 3, 4, and 5 ON TRANSPORTATION

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline - Construction	Once	6 Months (Winter)	Freight through Ports of Anchorage, Whittier, and Seward; traffic along the Dalton Highway; passengers through Anchorage, Fairbanks, and Deadhorse airports; personnel and materials by helicopter, boat, barge, and bus in the Prudhoe Bay area.	Minor - From overall project construction activities to ports resulting from 1% to 26% increase in freight traffic; <2% increase in freight traffic along the Dalton Highway; <4% increase in passenger and freight traffic through Anchorage, Fairbanks, and Deadhorse airports.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Local transportation of personnel and materials within the Prudhoe Bay area.	Negligible – Increase (over current levels) in freight traffic at ports and along the Dalton Highway; increase (over current levels) in passenger and freight traffic through Anchorage, Fairbanks, and Deadhorse airports; increase in local helicopter, barge, boat, and bus passenger and freight traffic within the Prudhoe Bay area.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionally	 3 Months (Winter) Unknown	N/A	None anticipated.	None anticipated.
Large Oil Spill	Rare	Unknown	Dalton Highway and Anchorage, Fairbanks, and Deadhorse Airports.	Minor – Focused commitment of transportation resources during the initial phase of spill response efforts, which would taper as efforts stabilized.	None anticipated
Abandonment	Once	3 to 6 Months	Freight through Ports of Anchorage, Whittier, and Seward; traffic on the Dalton Highway; passengers through Anchorage, Fairbanks, and Deadhorse airports; personnel and materials by helicopter, boat, barge, and bus in the Prudhoe Bay area.	Minor – From increased traffic along the Dalton Highway; increased transportation of equipment and materials through the ports and airport passenger service.	None anticipated.

Notes: < = Less than   % = Percent   N/A = Not applicable

TABLE 7.8-1
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON VISUAL/AESTHETIC CHARACTERISTICS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	Within a few miles of the construction activities associated with each alternative.	Minor - To oil field personnel from intrusion of equipment and lighting for ice road construction; to Nuiqsut residents due to a faint glow on the horizon as a result of lighting from construction activities.	None anticipated.
Ice Roads – Operations	Annually	All winter	6 to 9 miles (9.7 to 14.5 km) offshore route.	Minor - To oil field personnel from intrusion of equipment and lighting for ice road construction; to Nuiqsut residents due to a faint glow on the horizon as a result of lights from equipment for ice road construction.	None anticipated.
Island – Construction	Once	3 Months	Within a few miles of the construction activities associated with each alternative.	Minor – To Nuiqsut residents due to a faint glow on the horizon as a result of lighting from construction activities; to oil field workers from intrusion of equipment; area subjected to minor visual impacts of the island and facilities.	None anticipated.
Island – Operation/ Maintenance	Annually	15 years	Within 20 miles (32 km) of Seal Island.	Minor – To oil field workers and subsistence hunters from intrusion of equipment, personnel, the island, facilities, and the flare; to Nuiqsut residents as a faint glow on the horizon from lights. Negligible - To bowhead whales from visual impact as a result of infrequent flare operation.	None anticipated.
Offshore Pipeline – Construction	Once	3 Months (Winter)	Within a few miles of the construction activities associated with each alternative.	Minor – To oil field personnel from intrusion of equipment and lighting for pipeline installation; to Nuiqsut residents due to a faint glow on the horizon as a result of lighting from construction activities.	None anticipated.
Offshore Pipeline - Operation/ Maintenance	Rare	15 years	Within a few miles of the construction activities associated with each alternative.	None anticipated.	None anticipated.

TABLE 7.8-1 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, and 5 ON VISUAL/AESTHETIC CHARACTERISTICS

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Onshore Pipeline – Construction	Once	6 Months (Winter)	Within a few miles of the construction activities associated with each alternative.	Minor - To oil field personnel from intrusion of equipment and lighting during construction.	None anticipated.
Onshore Pipeline - Operation/ Maintenance	Weekly	15 years	Within a few miles of the construction activities associated with each alternative.	Minor - To oil field workers and subsistence harvesters from creation of the onshore pipeline approach and valve station and, for Alternatives 2 and 3, a new pipeline corridor through previously undeveloped areas.	None anticipated.
Gravel Mining Construction Operation	 Once Occasionall y	 3 Months (Winter)	Immediate vicinity of gravel mine site.	Minor - To oil field workers from intrusion of equipment and lighting; to Nuiqsut residents due to a faint glow on the horizon as a result of lighting from construction activities.	None anticipated.
Large Oil Spill	Rare	Unknown	Areas contacted by oil.	Negligible (Winter) - Reduction of quality of visual resources if spill occurred when viewer sensitivity would be low due to darkness and reduced level of outdoor activities; impacts would include staining of shoreline and presence of oil on the water. Minor (Summer) – Degradation of quality of visual resources if spill occurred when subsistence activities were ongoing (viewer sensitivity would be high). Visual impacts would include heavy equipment, staining of shoreline and tundra, plus presence of oil on the water.	None anticipated
Abandonment	Once	3 to 6 Months	Seal Island and pipeline route, depending on abandonment method.	Beneficial - If all equipment and facilities were removed and the island protection removed. Minor - During the abandonment process, impacts would be similar, but less than those of construction.	None anticipated.

Notes: km = Kilometers
N/A = Not applicable

TABLE 7.9-1
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON RECREATION

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Ice Roads – Construction	Once	All winter	N/A	None - No recreational activities occur in the project area during the winter.	None - No additional materials would be transported along the Dalton Highway.
Ice Roads – Operations	Annually	All winter	N/A	None - No recreational activities occur in the project area during the winter.	None - No additional materials would be transported along the Dalton Highway.
Island – Construction	Once	3 Months	N/A	None - Recreational activities do not occur in the project area.	Minor - To enjoyment of recreational activities along the Dalton Highway due to less than 2% increase in traffic for transporting equipment and construction materials.
Island - Operation/ Maintenance	Annually	15 years	N/A	None - Recreational activities do not occur in the project area.	None anticipated.
Offshore Pipeline – Construction	Once	3 Months (Winter)	N/A	None - No recreational activities occur in the project area during the winter.	None anticipated.
Offshore Pipeline – Operation/ Maintenance	Rare	15 years	N/A	None - Recreational activities do not occur in the project area.	None anticipated.
Onshore Pipeline – Construction	Once	6 Months (Winter)	N/A	None - No recreational activities occur in the project area during the winter.	None anticipated.
Onshore Pipeline – Operation/ Maintenance	Weekly	15 years	N/A	None - Recreational activities do not occur in the project area.	None anticipated
Gravel Mining Construction Operation	 Once Occasionall y	 3 Months (Winter)	N/A	None - No recreational activities occur in the project area during the winter.	None anticipated.
Large Oil Spill	Rare	Unknown	N/A	None anticipated	Negligible – Reduced enjoyment of recreational activities due to increased vehicle traffic along the Dalton Highway.

TABLE 7.9-1 (Cont.)
IMPACTS OF ALTERNATIVES 2, 3, 4, AND 5 ON RECREATION

Action/Event	Frequency	Duration	Scope	Direct Impacts	Indirect Impacts
Abandonment	Once	Winter 3 to 6 Months	N/A	None anticipated.	Negligible - For in-place abandonment, to recreational activities along the Dalton Highway due to the possible increase (% unknown) in traffic for transporting materials from the North Slope. Minor - For facility removal, to recreational activities along the Dalton Highway due to the increase (% unknown) in traffic expected for transporting materials from the North Slope.

Notes: N/A = Not applicable
% = Percent