CHAPTER 10.0

CUMULATIVE EFFECTS

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10.0 CUMULATIVE EFFECTS

10.1 INTRODUCTION

This chapter presents an evaluation of the cumulative effects associated with development of the Northstar Unit in addition to existing development and future actions. Cumulative effects are defined in 40 CFR 1508.7 as effects on the environment which are expected to result, "...from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions... Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time."

The Council on Environmental Quality provides additional guidance concerning the evaluation of cumulative effects. In its handbook, Considering Cumulative Effects Under the National Environmental Policy Act (NEPA) (January 1997), the Council on Environmental Quality suggests the following:

- "determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions;
- identify significant cumulative effects and focus on truly meaningful effects;
- address additive, countervailing and synergistic effects;
- exclude future actions from the cumulative effects analysis if the actions are outside the geographic boundaries established for the cumulative effects analysis; and
- address uncertainty through monitoring."

This cumulative impacts analysis involved four distinct activities, including:

- Determination of the geographic scope of the past, present, and reasonably foreseeable future actions considered.
- Describe the individual actions which may contribute to cumulative effects.
- Assess available information concerning environmental resources, Northstar Development Project (Northstar Project) effects, and identified past, present, and foreseeable future actions for the purpose of identifying potential issues which require further evaluation.
- Investigate identified potential issues and present the results of that investigation.

The geographic scope of actions considered in this analysis is discussed in Section 10.2. The determination of specific actions addressed is described in Section 10.3, and a specific list of foreseeable

future actions is presented. Sections 10.4 through 10.8 present the determination of potential cumulative effects issues, and an evaluation of those issues identified. As explained in greater detail in the remainder of this Environmental Impact Statement (EIS) chapter, the principal issues identified by this process and review of comments from the public during the EIS scoping and draft review processes include:

Issues/Concerns	Section
· What is the geographic area addressed by the cumulative analysis?	10.2
· What activities other than oil and gas development are considered in the cumulative impacts analysis?	10.3
· What past, present, and reasonably foreseeable future actions are expected to contribute to cumulative impacts?	10.3
· Would the Northstar Project contribute to cumulative effects by facilitating the development of other foreseeable future projects?	10.3
· Would the Northstar Project contribute to cumulative impacts of oil transportation on TAPS or the Valdez Terminal?	10.3
· What cumulative effects to the physical environment are expected?	10.4
· Are cumulative freshwater demands expected to result in substantial changes in lake water quality?	10.4
· How would the proposed action and other North Slope oil developments contribute to regional air quality problems, especially arctic haze?	10.4
· Are cumulative air quality impacts likely to cause adverse health effects?	10.4
· How would the proposed action contribute to concerns regarding cumulative effects on global climate?	10.4
· What cumulative effects to the biological environment would be expected?	10.5
· Would cumulative activity result in disturbances to polar bears and ringed seals?	10.5
· Would cumulative construction activity and routine project operations result in a significant loss of tundra vegetation?	10.5
· Would cumulative construction activity, freshwater demands, and gravel extraction result in a significant loss of wetlands?	10.5
· Would cumulative activity result in disturbances to caribou?	10.5
· Would cumulative activity (especially helicopter operations) result in disturbances to spectacled or Steller's eiders, both threatened species?	10.5
· Would cumulative activity and related noise result in significant disturbances to bowhead whales?	10.5
· What cumulative effects to the human environment are expected?	10.6
· How would cumulative activity or access restrictions affect subsistence hunting?	10.6
· How would cumulative activity and related noise affect subsistence whaling?	10.6
· What cumulative, long-term land use changes are expected?	10.6
· What cumulative effect on the visual character of the North Slope is expected?	10.6
· What cumulative effect on State of Alaska revenues is expected from existing and foreseeable future actions?	10.6
· What is the cumulative probability of a major oil spill, and what is the Northstar Project	10.7

Issues/Concerns	Section
contribution to this probability?	
· What is the cumulative probability of two or more major oil spills within a 5-year period, and what is the Northstar Project contribution to this probability?	10.7
· Would any biological resources be affected differently from cumulative exposure to multiple spills than as described for individual spills in Chapter 8.0 of the EIS.	10.7
· What cumulative effects would result from two major spills within a 5-year period, with specific consideration of population effects on spectacled eiders, other sea duck species (common eiders, oldsquaw, king eiders), polar bears, and bowhead whales?	10.7
· Could a single spill or multiple oil spills adversely affect subsistence hunting of polar bear?	10.7
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· What cumulative effects of noise are expected?	10.8
· Could multiple offshore noise disturbances cause large-scale whale migration path changes and resulting effects on subsistence whaling?	10.8
· Could helicopter activities associated with multiple projects result in significant combined noise disturbances in common travel corridors?	10.8

The remainder of this chapter presents the results of the cumulative impact analysis process, and specifically addresses each of the issues listed above.

10.2 GEOGRAPHIC AREA ADDRESSED IN THE CUMULATIVE EFFECTS ANALYSIS

The geographic area addressed in this cumulative effects analysis was determined by evaluating the potential impacts of the Northstar Project described elsewhere in this EIS, and considering the geographic distribution of other past, present, and reasonably foreseeable future actions that could result in cumulative effects. This effort resulted in the determination of a geographic area (referred to as the cumulative impact area) including an onshore area from the Harrison Bay area (including the National Petroleum Reserve, Alaska [NPRA]) to the Kaktovik area, and extending seaward to include state waters and federal Outer Continental Shelf (OCS) lease areas encompassed by federal Lease Sales 144 and 170 (Figure 10-1). This geographic area was used to identify the activities addressed in the cumulative effects analysis, but it does not limit the geographic scope of the impacts evaluated. The geographic area was defined based on what is known about past, current, or foreseeable development activities.

The geographic range of impacts addressed varies according to the specific resource and nature of impacts under consideration. In some cases, the impact area addressed may extend beyond the boundaries of the geographic limits of the cumulative impact area. For example, the cumulative effects of noise could affect bowhead whale migration and, thereby, adversely affect subsistence whaling and Inupiat culture both in the immediate vicinity of the project as well as points along the whales' migratory path. It is conceivable that cumulative effects on whales could adversely impact subsistence whaling as far west as Points Barrow, Hope, and Lay (although it is highly unlikely that these effects could extend this far). Other cumulative impact issues may focus on a smaller geographic area within the cumulative impact area. This variation of geographic scope of the impact analysis is intended to allow the EIS to

present a complete view of cumulative effects to which the Northstar Project contributes, and to provide a focus on meaningful cumulative effects. The specific geographic range of each impact evaluation was determined by a review of the nature of the cumulative issues (regional concerns generally required broader geographic consideration), and an evaluation of the specific contribution of the Northstar Project. In addition to the focused evaluation of potential combined effects of the Northstar Project and other actions within the cumulative impact area, this analysis considers common oil transportation systems (Trans Alaska Pipeline System [TAPS], Valdez Terminal, and west coast tankering routes), potential regional effects on subsistence whaling, and global climate issues.

In addition to the cumulative impact analysis in this chapter, the cooperative agencies have also reviewed the Biological Assessment (Appendix B), which was prepared to satisfy a different regulatory requirement. Under the Endangered Species Act (ESA), the Biological Assessment evaluates potential Northstar Project impacts on any endangered or threatened species found in the immediate vicinity at the project, as well as along foreseeable Northstar oil transportation routes. Two of the cooperative federal agencies participating in the preparation this EIS, the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) have carefully reviewed the Biological Assessment and have prepared their Biological Opinions concerning project impacts on ESA-listed species (Appendix M).

10.3 PAST, PRESENT, AND REASONABLY FORESEEABLE FUTURE ACTIONS

Past and present development within the cumulative impact area, ongoing community growth, and subsistence hunting and whaling activities were considered, along with oil and gas development, in the evaluation of potential cumulative effects. No substantial community growth or specific non-oil related future projects were identified which would materially influence the cumulative effects analysis. Subsistence

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activities are addressed as traditional activities subject to potential cumulative effects of oil development. The cumulative impacts analysis also evaluates potential combined effects on resources associated with oil development-related impacts and traditional subsistence activities. If these impacts are expected to result in resource management actions which could adversely affect traditional subsistence activities, they are identified as potential adverse effects on subsistence.

10.3.1 Past Oil and Gas Activity

Oil and gas exploration and production activities have occurred in the Alaska North Slope/Beaufort Sea region for over 30 years. The Prudhoe Bay oil reservoir was discovered in 1968 and generated substantial interest in the exploration for, and development of, oil and gas resources in this area. Since the first State of Alaska lease sale in December 1959, the State has leased over 32 million acres (13 million hectares) through sales that primarily offered North Slope/Beaufort Sea leases. Currently, active state leases north of the Brooks Range total approximately 16.43 million acres (6.65 million hectares). The most recent state sale on the North Slope was Lease Sale No. 87, held June 24, 1998. There have been approximately six federal oil and gas lease sales within federal waters of the Alaskan Beaufort Sea, beginning with the Joint State Federal Sale held in December 1979. The most recent federal sale in the Alaskan Beaufort Sea was Lease Sale 170, held in August 1998. These sales resulted in the leasing of 688 tracts, of which 96 remain active. Approximately 30 wells have been drilled in these leases, of which nine have been determined producible (USDOI, MMS, 1998:IV-1-21).

Since the first production well was drilled in the Prudhoe Bay unit, North Slope oil reservoirs have produced a cumulative total of 11.57 billion barrels of oil through the end of 1996 (USDOI, BLM, 1998: IV-A-43). Production from North Slope reservoirs peaked in 1988 at 2 million barrels per day (barrels/day) of oil, and declined to 1.45 million barrels/day of oil by 1995 (ADNR, 1996:5-40; USDOI, MMS, 1998:IV-A-21). The activities associated with oil and gas industrial development which occurred in association with this historic production included the creation of an industry support community and airfield at Deadhorse, as well as an interconnected industrial infrastructure including roadways, pipelines, production and processing facilities, gravel mines, and docks. (For an overview of present and reasonably foreseeable future activities associated with oil development in the Arctic, refer to Sections 3.4.2.1, 10.3.2, and 10.3.3). TAPS was developed to transport North Slope crude oil to a year-round marine terminal in Valdez, Alaska. TAPS operations were initiated in 1977, and this pipeline is used to transport the entire production from the North Slope. TAPS currently operates with substantial available capacity.

10.3.2 Present Oil and Gas Activity

The industrial facility infrastructure referred to above currently includes interconnected facilities from the Oliktok Point area in the west to the Sagavanirktok River in the east. Recent construction of the Badami facilities at Mikkelsen Bay, located about 25 miles (40 kilometers [km]) east of Prudhoe Bay, and its pipeline connection to the Endicott common carrier pipeline, represent the easternmost extent of current oil production activities. No year-round roadway connections between this area and other existing industrial areas exist. Recently developed Tarn facilities are located approximately 18 miles (29 km) west

of the Kuparuk River Unit, and are connected to Kuparuk Unit facilities by a new gravel roadway and pipeline. Industrial facilities currently in place produce, transport, and process production from the Kuparuk, Milne Point (including Schrader Bluff and Cascade), Prudhoe Bay, Lisburne (including Niakuk and Point McIntyre), and the nearshore Duck Island (Endicott) Units. Approximately 1,123 miles (1,807 km) of pipelines connect producing wells to production processing facilities, and then to the TAPS. Approximately 7,000 acres (2,833 hectares) of land are developed for drill pads and processing facilities, and facilities are connected by approximately 360 miles (579 km) of gravel roads. Fifteen gravel mines totaling approximately 1,600 acres (648 hectares) have been developed for source material; however, only seven of the mine sites are currently in use (or active). The North Slope has on the order of 1,800 oil production wells, 100 gas injection wells, and 600 water injection wells.

From 1977 through 1996, approximately 11.57 billion barrels of oil have been produced from these reservoirs. As of 1995, North Slope production was approximately 1.45 million barrels/day of oil, 9 billion standard cubic feet per day of gas, and 2 million barrels/day of water (BPXA, 1997:24). Oil production is forecast to continue from currently developed oil fields at diminishing rates through at least 2020 (ADNR, 1997: 5-40). Detailed descriptions of the facilities are presented in Section 3.3.2 and summarized in Table 10-1. Existing facilities are shown on Figure 10-2.

Crude oil produced from all existing fields is transported to world markets via the TAPS. As of 1995, TAPS throughput was 1.45 million barrels/day oil. The TAPS is expected to continue to operate through the year 2015 (Thomas et al., 1993:1-8).

10.3.3 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions addressed in the analysis of cumulative effects include the projected decline in production from existing oil fields, all currently identified proposals for new development, and an estimate of potential exploration and development associated with recent and presently proposed lease sales. This cumulative analysis is focused upon identifiable existing and future oil and gas activities which are reasonably expected to occur during the life of the proposed Northstar Project, a period of approximately 15 years. A summary of the reasonably foreseeable future actions addressed by this analysis is presented in Table 10-2.

The 1995 oil production rate of 1.45 million barrels/day from existing North Slope development is projected to decline to 0.944 million barrels/day oil by 2005, and to 0.292 million barrels/day oil by 2020 (ADNR, 1997:5-40). This decline will result in substantial available capacity in TAPS, as long as this system remains operational. The U.S. Department of the Interior has suggested that TAPS would require extensive modification to continue to operate at less than the projected 2015 throughput of 0.384 million barrels/day

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(USDOI, MMS, 1998:IV-A-23). Capacity also may become available in many oil field facilities and pipeline systems during this period, although only common carrier pipelines would be readily accessible to all operators.

Remaining oil reserves for the North Slope/Beaufort Sea area are forecast to be substantial. Producible reserves between 6 and 11 billion barrels have been estimated in state leased areas, and another 0.57 to 1.22 billion barrels are estimated in areas leased or proposed for leasing by the federal government. Total production from currently operating and identified fields which are expected to be developed is estimated to be 6.47 billion barrels from 1997 to 2020 (USDOI, BLM, 1998:IV-A-43). In addition to the continued enhancement of production from the existing fields described in Section 10.3.2, these projected future production estimates consider additional future development.

10.3.3.1 Foreseeable Future Development

Alpine: Plans to develop ARCO Alaska Inc.'s (ARCO's) Alpine Unit, located 34 miles (55 km) west of Kuparuk in the western Colville River Delta, were announced October 2, 1996 (ARCO, 1996:1-4). Original oil in place is estimated at 800 million to 1 billion barrels, with 250 to 300 million barrels potentially recoverable using current technology (Nelson, 1996:30). A portion of the interest in Alpine is owned by the Arctic Slope Regional and Kuukpik Corporations, which makes it the first North Slope oil discovery with Native-owned mineral and surface rights. Part of the development plan may provide the nearby town of Nuiqsut with natural gas from the Alpine development.

Six wells, four side-track wells (a well drilled from an existing wellbore that is directionally drilled to another point), and a three-dimensional seismic survey indicate that the reservoir is approximately 10 miles (16 km) long, covering approximately 40,000 acres (16,188 hectares). Development is proposed from two gravel pads connected by 3 miles (4.8 km) of gravel road. One gravel pad, Alpine Pad 1, is approximately 85 acres (34.4 hectares) in size and will be used for the central oil processing facility, employee accommodations, maintenance facilities, and some drilling equipment. The second gravel pad, Alpine Pad 2, will be used for wellheads. A 34-mile (55 km) long pipeline will connect Alpine production to the Kuparuk pipeline, and TAPS. Daily production is expected to peak between 50,000 and 80,000 barrels/day oil, and production could start as early as the year 2000 (ARCO et al., October 1996:2-1). The oil transport pipeline would cross the Colville, Kachemak, and Miluveach Rivers. The pipeline will be installed under the Colville River by directional drilling for a distance of approximately 4,000 feet (ft) (1,219 meters [m]). The right-of-way was granted by the Alaska Department of Natural Resources on December 15, 1998. In addition, a seawater pipeline will transport water for waterflood from Oliktok Point to water injection wells.

Review of local, state, and federal permit applications required for the Alpine project was completed in early 1998. Construction activities began soon thereafter, and gravel fill has been placed for Pad 1 and the airstrip. Directional drilling of two holes for the pipeline has also been accomplished. Further construction is planned during the 1998/99 winter season.

Liberty Prospect: Lease Sale No. 144 resulted in a $10.6 million bid from BP Exploration (Alaska) Inc.

(BPXA) for the reservoir discovered in 1982 by Shell Oil Company from Tern Island. Tern Island is a manmade gravel island built for exploration drilling. It lies off of Foggy Island Bay about 20 miles (32 km) east of Prudhoe Bay, 10 miles (16 km) east of Endicott processing facilities, and 5 miles (8 km) north of the mainland in federal waters. The water depth averages about 20 ft (6.1 m) over the reservoir. Three exploration wells were drilled by Shell from Tern Island, which is currently abandoned and eroding. The Minerals Management Service (MMS) classified the three wells as containing producible quantities of oil. BPXA drilled an additional well in the winter of 1996/1997 from Tern Island. Based upon the results of the exploration wells, BPXA has proposed that the Liberty Prospect be developed from a new gravel island. BPXA estimates the Liberty reservoir has 120 million barrels of recoverable crude oil. Construction activities are proposed by BPXA for the 1999/2000 winter season, with first production anticipated by the end of 2000. A buried subsea pipeline is being considered to bring production to shore. The length and route of the offshore and onshore pipeline has not yet been determined. Development/production activities from Liberty require an EIS for compliance with NEPA. The MMS is in the process of preparing an EIS on the proposed development project.

10.3.3.2 Additional Potential Projects During the Northstar Project Lifetime

Additional projects are expected to be proposed and developed during the Northstar Project lifetime. Although the precise nature of individual projects cannot be accurately determined, the location of known discoveries provides information that may help identify the general location of future development. These discoveries are listed in Table 10-2, and are shown on Figure 10-2. Collectively, they are estimated to contain up to 1.38 billion barrels of oil (USDOI, BLM, 1998:Table IV.A.5-6). This total oil resource estimate is approximately double the amount associated with currently identified projects (Northstar, Alpine, and Liberty). Development of the discoveries listed in Table 10-2 is expected to occur in approximately 10 years, and would overlap with the last 5 years of the Northstar Project. These include the Point Thomson, Sourdough, Sandpiper, Hammerhead, and Kuvlum prospects.

10.3.3.3 Recent and Planned Lease Sales

Although less definite than the previously discussed foreseeable future developments, results of the most recent lease sales for federal and state lands may also lead to development. Seismic surveys and exploratory drilling are expected to occur during the Northstar Project life, and projections included in lease sale documents anticipate discoveries and production operations during this period.

State Lease Sales: State Sale No. 86A resulted in a total of five bids received from ARCO, Anadarko Petroleum Corporation, and Union Texas in the Colville River area. Thirteen tracts totaling approximately 15,484 acres (6,266 hectares) were offered for lease. The highest bid was $903,528 for a single tract. A total of 5,901 acres (2,388 hectares) were leased by the three companies (ADNR, 1996:1). An announcement by ARCO, Anadarko Petroleum Corporation, and Union Texas on October 2, 1996, revealed that the newly leased property lies adjacent to the Alpine discovery (ARCO, 1996:1-4). Specific development/production expectations associated with this lease sale are not available.

Proposed State Sale Beaufort Sea Areawide 1999 (combination of proposed Sales 83 and 89) scheduled

for October 1999, consists of approximately 2 million acres (809,400 hectares) of state-owned tidal and submerged land in the Alaskan Beaufort Sea, between the Canadian border and Point Barrow, and some coastal uplands acreage located along the Beaufort Sea between the Staines and Colville Rivers. Hydrocarbon potential is considered low to moderate. Additional Beaufort Sea areawide sales are planned by the State in 2000 and 2001.

State Sale No. 87, the state's first area-wide lease sale, occurred in June 1998. Approximately 5.1 million acres (2 million hectares), divided into 1,225 tracts, between the Colville and Canning Rivers were offered. The sale resulted in a total of 168 bids on 139 tracts by 13 bidders. A total of 558,080 acres (225,855 hectares) were leased at an average price of $98.67 per acre (ADNR, 1998).

The State of Alaska has also announced plans to offer North Slope Foothills leases in 2001. The area under consideration for lease offerings includes State-owned lands between the NPRA and Arctic National Wildlife Refuge (ANWR), south of the Umiat Baseline and north of the Gates of the Arctic National Park and Preserve. The gross proposed sale area is in excess of 7 million acres (2.8 million hectares). Hydrocarbon potential is considered moderate.

Federal Lease Sales: Federal Offshore Lease Sale No. 170 was held by the MMS on August 5, 1998, focusing on the central portion of the Beaufort Sea. Thirty-one bids were received on 29 bidding units. Companies participating in the bidding were ARCO with Chevron U.S.A. Inc., BPXA separately and jointly with Chevron U.S.A. Inc., Petrofina Delaware, Inc., and Phillips Petroleum Company. BPXA submitted the highest bid, $911,922, for an area approximately 4 miles (6.4 km) offshore and 20 miles (32 km) to the east of Prudhoe Bay, north of the Duck Island Unit. This bid was rejected based on a determination that the bid was below the fair market value.

Phillips placed bids on 13 bidding units. Eight of them are in federal waters north and east of Cross Island. The remaining five are north of the McClure Islands. Petrofina bid on seven bidding units. One of the bidding units is located adjacent to and immediately northwest of the Sandpiper Unit, three bidding units are east of the McClure Islands, and the remaining three bidding units are north of Maquire/Flaxman Islands, one of which is adjacent and immediately south of the Hammerhead Unit. BPXA placed bids on seven bidding units. Two bids placed jointly with Chevron were for bidding units located in Federal waters offshore of the Point Thomson Unit. The remaining five bids were submitted by BPXA alone and were for two bidding units immediately east of the Northstar Unit, and three bids were placed on bidding units north of the Duck Island Unit, one of which was the rejected bid. ARCO and Chevron bidding jointly placed bids on two bidding units east of Cross Island.

The MMS has estimated total producible reserves from existing federal leases to be 0.22 to 0.55 billion barrels of oil. MMS estimates of oil resources to be discovered and developed associated with the proposed Lease Sale No. 170 are 0.35 to 0.67 billion barrels. These potential resources are based on estimates of production from fields that have not yet been discovered and are somewhat uncertain. However, these estimates have been considered in the cumulative analysis in this EIS.

The current federal 5-year lease sale plan for OCS waters covers sales to be conducted between 1997 and

2002. Federal Lease Sale No. 176 in the Alaskan Beaufort Sea has been scheduled for the year 2000. Specific offerings of this lease sale and related production potential are not presently known.

Future federal lease sales could result from a U.S. Supreme Court Dinkum Sands decision. The Dinkum Sands lawsuit was filed in U.S. Supreme Court by the U.S. Department of the Interior against the State of Alaska to settle 13 questions of merit, including one that defined the seaward boundary of ANWR. The state claimed that it owned the lagoon areas stretching across the northern coast of the refuge; the U.S. government claimed state ownership began at the barrier islands. The U.S. Supreme Court decision stated that the lagoon area belongs to the federal government. The amount of acreage involved may be as much as 100,000 acres (40,470 hectares) (Cashman, 1996:1).

Federal NPRA land is currently under evaluation for oil resource potential. An Integrated Activity Plan and EIS has been prepared for the Northeast Planning Area of the NPRA, and lands within this planning area will be offered for sale in the summer of 1999. An additional evaluation west of the Northeast Planning Area may also be considered in future planning efforts. Oil resources expected in the Northeast Planning Area total 130 to 600 million barrels. An additional 130 to 1,200 million barrels of oil are estimated to occur in the western NPRA (USDOI, BLM, 1998:Table IV.A.5-7).

10.3.3.4 Resource Evaluation Activities

Arctic National Wildlife Refuge: ANWR encompasses 19 million acres (7.7 million hectares), extending from the Canning River to the Canada border. ANWR was established in 1980 as part of the Alaska National Interest Lands Conservation Act. Congress set guidelines for the study of a 1.55 million-acre (627,285 hectare) area referred to as Section 1002. Petroleum exploration and development activities and support infrastructure are prohibited in ANWR. One exploration well was drilled in 1986 by Chevron on Native-owned land near the village of Kaktovik adjacent to Section 1002. All results from the exploration well, Kaktovik Inupiat Corporation (also known as the Jago River-1) remain confidential.

10.3.3.5 New Regional Pipeline Systems

Trans Alaska Gas Pipeline System: The Trans Alaska Gas Pipeline System has undergone NEPA review and construction permit application approval; however, it is considered highly speculative. The project has been proposed for many years, yet no agreement exists to purchase gas from North Slope producers or to sell gas to customers in commercial quantities. The gas pipeline would be an approximately 800-mile (1,287 km) pipeline that follows the existing TAPS corridor to transport natural gas in the North Slope to a new liquefied natural gas facility at the Port of Valdez. Yukon Pacific Corporation is the permit holder.

Alaska Natural Gas Transmission System: The Alaska Natural Gas Transmission System has undergone permit application review and approval. The Canadian portion of this project is in place. The installation of the Alaska portion is considered highly speculative, and no gas purchase agreement with North Slope producers currently exists which would justify the construction of the Alaskan segment of this system.

In addition to these two proposed gas pipeline systems, other potential delivery systems for North Slope natural gas have been discussed, such as using gas-to-liquid (white crude) technology and transporting the white crude through the TAPS system. Such options are also highly speculative at this time.

10.3.4 Northstar Development Project Effect in Combination with Past, Present, or Reasonably Foreseeable Future Actions

A concern has been raised regarding the Northstar Project's potential influence on other prospective oil developments on the North Slope. This concern is related to two primary topics: the potential that technical development and agency approval of a subsea pipeline from an offshore island could result in additional development of this type; and the potential that the development of an industrial infrastructure could facilitate further developments, such as Sandpiper (offshore) and Gwydyr Bay (nearshore and onshore).

With regard to the influence of the Northstar subsea pipeline technology, the technological issues have already been addressed by BPXA's project design. Agency approval or denial of the Northstar Project could influence the design proposed for other future projects if the agency action is clearly associated with the subsea pipeline project element. An action to deny Northstar would not necessarily eliminate other offshore projects, but it could affect project economics or influence project design details. Approval of the Northstar Project would not obligate agencies to approve any other project, but it could suggest to potential project developers that subsea pipelines are generally acceptable. Because approval of Northstar does not create an agency obligation concerning other projects, it is not considered a precedent that would remove any obstacle or environmental control currently applicable to other projects. The cumulative impacts analysis in this EIS does, however, presume that these projects will proceed (i.e., they are reasonably foreseeable).

Development of additional industrial infrastructure could improve project economics associated with the development of other prospects, such as Sandpiper and those in Gwydyr Bay. Currently available information concerning those prospects is not sufficient to allow an evaluation of the likelihood that they would or would not be developed in the absence of the Northstar infrastructure. The presence of the Northstar Project infrastructure, such as a production island and undersea pipeline, would not, however, obligate the development of these resources. The development of these prospects is considered in the cumulative impacts analysis, as reasonably foreseeable, and it is reasonable to expect that the Northstar infrastructure would be used if sufficient capacity is available.

The current oil transportation system, including TAPS and the Valdez Marine Terminal, were used to transport the peak North Slope oil production of 2.0 million barrels/day in 1988, and 1995 production of 1.45 million barrels/day. The State of Alaska estimates the combined production from existing and to-be-developed fields will result in progressively declining production, to a rate of 0.384 million barrels/day by 2015 (USDOI, MMS, 1998:IV-A-23). The TAPS and Valdez facilities are expected to continue to operate throughout the projected Northstar Project lifetime, regardless of the decision concerning the Northstar Project. The contribution of oil produced from the Northstar Unit will not offset the overall decline in

North slope oil transported through the TAPS. Therefore, production from the Northstar Unit will not increase the current risk of an oil spill. The analysis of potential effects of the TAPS pipeline and tankering system is incorporated by reference from Chapter IV of the "Outer Continental Shelf Oil and Gas Leasing Program: 1997-2002, Final Environmental Impact Statement, August 1996."

That analysis included consideration of impacts on physical, biological, and human resources associated with accidental oil spills from tankering TAPS oil to west coast ports. The analysis concluded that some degree of impact is likely on most environmental and socioeconomic resources. However, in virtually all cases, these impacts should not result in permanent change or loss of these resources.

10.3.5 Cumulative Impact Evaluation Process

The evaluation of potential cumulative impacts involves consideration of combined effects from multiple impact sources. The past, present, and reasonably foreseeable future actions described in Sections 10.3.1, 10.3.2, and 10.3.3 provide information concerning activities which may result in cumulative impacts. Although the specific location, timing, and level of activity associated with some of the individual actions listed are uncertain, the listed activities provide an overall view of the extent and level of industrial activity within the cumulative impact area coincident with the Northstar Project. To evaluate the combined effects of these activities, the EIS considers these activities as a collection of individual impacts distributed across the geographic range of the cumulative impact area (Figures 10-1 and 10-2). Several features of these impacts are considered to evaluate potential cumulative impacts, including:

- Intensity (magnitude of each individual impact).
- Scale (geographic area subject to each individual impact).
- Duration (persistence of each impact over time).
- Timing and frequency (schedule of impact occurrence, and consideration of potential impact recurrence).
- Synergy (potential interaction of different impacts to different, but related, environmental resources).
- Likelihood (effects that are uncertain are considered in the context of cumulative risk to identify potential impact concerns that might be overlooked in a single-project analysis).

The cumulative impact evaluation is intended to provide information concerning environmental effects that may be significant when the cumulative contributions of past, present, and reasonably foreseeable future actions are considered, even though the effects of individual actions may be minor. In some cases, this analysis addresses issues which have not been extensively studied, and may involve substantial professional judgement. This effort is further complicated by the level of detail available concerning future actions. As a result, many of the conclusions regarding cumulative effects are presented as a

qualitative statement based on a general level of future activity, rather than a quantitative impact analysis addressing multiple clearly defined projects. The reasoning applied to each environmental issue is explained, along with the cumulative analysis results, to communicate the basis of the conclusions presented.

Decisions concerning the evaluation of cumulative effects using individual development-specific details, or more general regional-scale information, are accomplished based on the nature of potential impacts under consideration and the availability of specific information. Where the analysis of impacts is focused on the location and timing of specific activities, information concerning past, present, and foreseeable future actions presented in Sections 10.3.1, 10.3.2, and 10.3.3 provides the basis of this analysis. Environmental topics which require a broader consideration of the level of industrial activity are addressed by consideration of expected overall oil production rates and evaluation of the related exploration and development activity.

Regional-scale information used in the determination of cumulative impacts accepts the potential scale of oil development projected by the State of Alaska. The state estimates that production from existing development and known fields will total 6.47 billion barrels of oil from 1997 to 2020 (USDOI, BLM, 1998: IV-A-46). Based on the relative reserves associated with expected and possible sources of future production presented in Table 10-3, this production is expected to be derived from the following sources:

- Existing developed onshore fields - 59 percent (%)
- Existing developed offshore fields - 2%
- Proposed or possible new onshore fields - 21%
- Proposed or possible new offshore fields (including Northstar) - 18%

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In other words, future production estimates assume that approximately 39% of total production will be derived from new development, which is nearly evenly divided between onshore and offshore prospects. The Northstar Project would represent approximately 2.4% of the total currently projected North Slope oil production between 1997 and 2020.

The remainder of this EIS chapter presents the results of the cumulative effects analysis. As indicated in the following text, these impacts are not necessarily limited by the geographic boundaries of the cumulative impact area. Impacts of multiple activities which extend beyond the cumulative impact area are described fully where they are identified. In some cases, the cumulative analysis focuses on a smaller geographic area, and may specifically address overlapping or additive effects of a small number of identified existing and future actions to clearly present a specific issue. This flexible nature of the cumulative analysis is intended to accomplish the NEPA goal that the potential meaningful cumulative effects should be clearly presented. The specific analysis conducted in relation to each environmental issue is addressed in the issue-specific text in the remainder of this chapter.

10.4 CUMULATIVE EFFECTS TO THE PHYSICAL ENVIRONMENT

Existing and reasonably foreseeable future actions have the potential to result in cumulative effects to the geologic and hydrologic environment, air quality, marine water quality, and sea ice. The nature and significance of these effects and the expected Northstar Project contribution are discussed below.

10.4.1 Geology and Hydrology

With the exception of a large oil spill, no significant impacts to geologic conditions, soils and sediments, hydrologic processes, or freshwater quality were identified in connection with the Northstar Project (Section 5.3.2). Minor impacts were identified in relation to several concerns, including: disturbance and deposition of sediments on the seafloor, localized erosion at the pipeline landfall site, permafrost thaw-related subsidence at the island site and pipeline landfall, altered subsurface geology from injection of wastes, riverbed and bank modification, reduced sediment and soils quality, and water quality effects of freshwater withdrawals. Most of these effects are localized, and no specific overlapping effects associated with reasonably foreseeable future projects have been identified. The primary areas of potential cumulative impacts involve the potential for additional gravel extraction in the Kuparuk River associated with future Gwydyr Bay or Sandpiper projects, and potential water quality effects of cumulative freshwater requirements associated with these projects in combination with Northstar requirements. On a regional scale, the increasing number of localized disturbances and geographic expansion of the range of these disturbances beyond the existing industrial areas is another cumulative concern.

Gravel extraction, fill placement, and other soil disturbances associated with the construction of oil field facilities have the potential to affect surface runoff patterns and modify the soil's thermal regime. This can result in minor changes to drainage patterns or permafrost, and may cause an expansion of the

affected area beyond the original disturbance. The specific details of the foreseeable future actions have not been clearly defined, and the total amount of gravel fill and extraction cannot be determined. Advances in project design based on over 20 years of experience have resulted in the development of successful approaches to help minimize these impacts. The Northstar Project have been designed to minimize trenching and placement of gravel fill in onshore areas, and the location of the proposed gravel extraction site near the Kuparuk River mouth is expected to prevent the alteration of local drainage patterns. Project design incorporates winter pipeline construction and does not include new gravel roadways.

Extraction of freshwater for use in the construction of ice roads to support onshore and offshore oil and gas activities would increase as new actions are developed. Water withdrawal from authorized water sources (e.g., lakes, rivers) occurs during the winter in accordance with permit restrictions on water volume. Because freshwater is replenished during the spring and summer months, the cumulative effect on lake water quality due to increased freshwater use for road construction would be negligible.

The geographic expansion of oil field facilities outside of existing developed areas, related future development of gravel extraction sites, and reconstruction of roadways and pipelines to connect these facilities to the existing industrial infrastructure, will result in the cumulative effect of increasing the soil area disturbed and the number of water courses exposed to these impacts. However, proper facility design and application of construction practices that minimize this effect (such as winter construction) are expected to reduce these effects to temporary and localized impacts. As a result, regional cumulative effects are expected to be negligible.

10.4.2 Air Quality

No significant impacts to air quality were identified in connection with the Northstar Project (Section 5.4.2). Minor impacts were identified in relation to air pollutant emissions from construction and project operations. These emissions contribute to cumulative air quality issues related to the presence of industrial emissions in an otherwise undeveloped area, local residents' concerns regarding regional air quality degradation and related health effects, and contribution to global greenhouse gas emissions.

10.4.2.1 Regional Air Quality

Existing oil field development and related facilities have contributed to industrial emissions sources in an otherwise undeveloped area. By regulatory standards, to date this cumulative effect is not significant since the North Slope area complies with all National Ambient Air Quality Standards and State of Alaska Ambient Air Quality Standards. The cumulative introduction of multiple industrial emissions sources in an undeveloped area is, however, considered significant by some observers without regard to regulatory standards. Whether such emissions from Northstar (or combined with reasonably foreseeable future projects) would contribute to arctic haze is not known. Arctic haze is a circumpolar problem with many sources, and Northstar's contribution would be an incrementally very small addition. A similar situation exists in terms of Northstar's (and the cumulative air quality effects of the North Slope) affect on global climate change (See Section 10.4.2.3).

10.4.2.2 Human Health

Project compliance with current federal Clean Air Act requirements is mandatory, and the Alaska Department of Environmental Conservation administers a comprehensive permit program to protect air quality in this area. Achievement of air quality goals has been complicated by the transport of pollutants from other areas, and local residents have expressed concerns that “arctic haze” associated with regional air pollutants has affected human health by increasing the incidence of cancer and respiratory ailments. Studies which clearly link health statistics to arctic haze have not been conducted. Production associated with existing and reasonably foreseeable future actions is projected to decline during the life of the Northstar Project. As a result, cumulative contributions of air pollutant emissions from oil development are not expected to increase above current levels. The Northstar Project will contribute to the extension of industrial emissions sources into offshore areas, but its onshore emissions will be consolidated within the existing industrial developed area.

10.4.2.3 Global Climate Change

Industrial activities on the North Slope contribute to global greenhouse gas emissions, and the Northstar Project will add to this contribution. These contributions result from the direct combustion of fossil fuels by North Slope facilities, the combustion of fossil fuels associated with the transport and refining of produced oil, and the ultimate combustion of most of the oil produced as a fuel. Gas emissions resulting from hydrocarbon fuel combustion have been suggested as a potential contributor to atmospheric changes that could cause global climatic warming. Estimates of the importance of fossil fuel combustion to the total atmospheric burden of greenhouse gases vary widely, and resolution of this controversy is beyond the scope of this EIS. However, an attempt to summarize this issue and its relation to Northstar is offered below.

Earth’s Changing Climate: Evidence from ice cores, geological strata, lake beds, and other sources indicate that the earth’s climate is changing constantly. For any specific location, the climate likely has been both warmer and colder in the past than at the present. It also is certain that, in the future, climate at most locations can be expected to vary from what is generally considered normal today. Such changes

will occur with or without human influence. However, human activity may alter natural changes and cycles, either by augmenting or suppressing natural processes.

Knowledge currently available is inadequate for a full understanding of the dynamics of climate change and, at least in the near term, future changes will be difficult to predict with any level of confidence. It is known, however, that ice ages have occurred at approximately 100,000-year intervals for the last 3 million years. Apparently, the globe is currently experiencing a warm interval between successive cold periods. Moreover, concentrations of certain gases in the earth's atmosphere are changing. At present, levels of carbon dioxide are higher than they have been in the past 100,000 years. Carbon dioxide is one of the atmospheric gases frequently referred to as "greenhouse gases."

Human activities, beginning with the Industrial Revolution, are seen as the primary cause for the rapid increase in atmospheric carbon dioxide. Other greenhouse gases, including methane, chlorofluorocarbons, nitrous oxide, and water vapor also have been increasing. These "greenhouse gases" are assumed to be contributors to a "global warming" scenario or global increase in temperature. Computer models known as Global Climate Models (GCMs) indicate that increases in temperature will not be distributed equally around the globe, but are likely to be accentuated at higher latitudes, such as in the Arctic, where temperatures may rise more than the global average. Warming during the winter months is expected to be greater than warming during the summer.

On a regional basis, temperatures in Alaska and throughout the Arctic appear to have fluctuated considerably over the last few centuries. Since at least the mid-1970s, temperatures have warmed throughout much of Alaska. Most of the observed warming has occurred during the winter and spring. Overall, the temperature increases have been in the range of 3.6 degrees Fahrenheit (2 degrees Celsius), and the pattern has been similar to that predicted by the GCMs based on the increase in atmospheric greenhouse gases.

A climate that continues to change, as predicted by the GCMs, could have effects on the tundra ecosystem of the North Slope. The ultimate advantages and disadvantages of climate change for individual species of plants and animals are difficult to predict, and the structure of the future arctic ecosystem is not entirely clear. A warmer and wetter environment with a longer growing season is likely to have a strong positive effect on migratory birds by providing an increased period of time to raise their young. More productive aquatic food chains could benefit some ducks and loons. Conversely, an increase in abundance of deciduous shrubs, especially birch (less favorable caribou forage), and a decline in the abundance of grasses and sedges such as *Eriophorum vaginatum* (a particularly important food of calving caribou) could reduce the productivity of caribou habitats on the North Slope. Over decades, warming temperatures could result in the invasion of tundra habitat by taiga woody plants (taiga forests), a less favorable habitat for tundra mammals and some bird species, thereby adversely affecting their populations.

The rate of glacier, permafrost, and ice cap shrinkage remains a topic of scientific investigation. It appears fairly certain that many of the glaciers in the northern latitudes are receding. Century old records also suggest a reduction in the volume of permafrost. The respective contributions of natural and human

generated causes remain unknown; as noted above, natural variability, on the century-scale, is large in the Arctic.

Cumulative Contribution of North Slope/Northstar Oil Production: For the Northstar Project, methane emissions will occur primarily as leaks from facility components and evaporation from storage vessels. The dominant mechanism for carbon dioxide production will be combustion of fossil fuels in equipment (e.g., gas powered turbine compressors). Carbon dioxide will be generated in much larger quantities than methane on a mass emission basis.

Assuming the presumed connection between emissions of greenhouse gases and global warming is valid, the proposed project activities will contribute incrementally to this effect. The direct emissions of carbon dioxide and methane due to project construction and operation will be modest, consisting mostly of temporary fuel firing by construction equipment and ongoing fuel combustion by boilers, heaters, turbines, and mobile equipment (e.g., vehicles) at the project site. The project design includes reinjection of produced gas, rather than flaring. In terms of cumulative impacts in combination with all North Slope activities, it should be noted that overall oil production in the region is declining and is projected to decline further, with or without the addition of the Northstar Project. This implies that production decreases at other operating units and corresponding decreases in emission of greenhouse gases will offset the incremental effect of the project's emissions. Thus, in a regional sense, there will be a net decrease in greenhouse gas emissions relative to current and recent levels.

In particular, of the greenhouse gases produced locally on the North Slope, Northstar will contribute less than an estimated 1%. To accomplish this low emission level, Northstar's design incorporates measures such as the use of efficient turbine drivers, minimized flaring, waste heat recovery techniques, fuel gas pretreatment to reduce carbon dioxide content, etc., to reduce the emission of such gases. On a regional basis, the entire North Slope is an attainment area, i.e., National Ambient Air Quality Standards (national standards) are "attained" in this region.

The total greenhouse gas emissions due to Northstar (technically referred to as the total downstream emissions budget), including emissions related to crude oil production, tanker shipments, refinement, product transportation, product utilization, etc., have not been precisely computed, in part because the eventual end products (e.g., plastics, gasoline, paving materials, etc.) are not known. However, an estimate can be made of at least the end product contribution of greenhouse gas emissions. As a worst case, assume the entire carbon content of Northstar derived crude oil, as produced at the peak production rate, were to be completely converted to atmospheric emissions in the form of carbon greenhouse gases (notably, methane and carbon dioxide). The ratio of these carbon emissions to the estimated annual global carbon emissions due to the burning of fossil fuels would be on the order of 0.037%. Averaged over the 15-year project life of the Northstar Project, this worst case ratio is reduced by roughly a factor of two.

The calculations offered above overestimate the actual budget for carbon emissions from the consumption of possible end products of Northstar crude oil because many of the end products are not burned (e.g., solvents, paving materials, etc.). However, these calculations do not include emission contributions from

the production and shipping of crude oil, refining, end product transportation, and so forth, (i.e., the total downstream emissions budget). A recent study required by the World Bank computed the total downstream carbon emissions budget related to an oil development in Chad. This study included items such as those noted above and may be used to estimate the total downstream emissions budgets due to the Northstar Project. The carbon emissions budget for the Chad oil field development included: oil field operations including flaring, the use of a long overland pipeline with pump stations, tanker loading, marine shipping of crude from Africa to other continents, product refining, transportation of end products to bulk terminals and thereafter to marketing facilities, and finally the combustion of these end products by consumers. Linear scaling of the peak 225,000 barrels/day (Chad) production rate to that of a peak Northstar production rate (65,000 barrels/day) provides an estimate of peak annual downstream emissions budget, due to all activities ranging from Northstar production to end product consumption. This estimate is 0.045% of annual carbon greenhouse gas emissions from the worldwide production and use of fossil fuels.

The same linear scaling approach used in the World Bank Chad study can be applied to the total North Slope industrial activity and related oil production. The current cumulative North Slope industrial activity and resulting 1.45 million barrels/day oil production (and downstream use) represents approximately 1% of the global fossil fuel greenhouse gas emissions. During the life of the Northstar Project, North Slope oil production is projected to decline steadily. If reasonably foreseeable future development projects proceed, the North Slope oil production rate at the end of the Northstar Project's life (in 2015) is projected to be 1.21 million barrels of oil per day. This production rate and related fossil fuel combustion would represent approximately 0.83% of the current global fossil fuel greenhouse gas emission rate. Overall, the cumulative contribution of North Slope oil production to global greenhouse gas emissions is expected to decline, and the Northstar Project contribution is negligible. It should also be noted that one of the principal sources of greenhouse gas emissions associated with oil production activities, routine flaring of produced gas, has been eliminated from the Northstar Project by the BPXA design which incorporates the reinjection of produced gas.

As stated previously, estimates of the importance of fossil fuel combustion to the total atmospheric burden of greenhouse gases vary widely. From the results presented above, it is clear that North Slope cumulative activities and related production represent a small portion of the worldwide fossil fuel-related contribution, and Northstar specific contributions represent such a small component as to be nearly immeasurable.

10.4.3 Marine Water Quality and Sea Ice

No significant impacts to marine water quality were identified in connection with the Northstar Project (Section 5.5.2). Minor impacts, associated with project construction and maintenance, to water quality in the vicinity of Seal Island and along the offshore pipeline route were identified. Other cumulative water quality issues have been identified in relation to operational discharges from industrial activities and water circulation effects of shore access structures, spoils disposal, and construction dewatering. BPXA's

Northstar Project is currently designed to eliminate these impacts by eliminating most of the discharges to water originally proposed.

Turbidity caused by gravel placement, trenching and burial of marine pipelines, creates temporary localized turbid plumes during the construction period, and possibly during portions of the first open water period following construction, by resuspension of disturbed sediments. The extent of these turbidity effects has been estimated to affect about 1 square mile (2.6 square km [km^2]) by the MMS (USDOI, MMS, 1998:IV-G-1). Sediment monitoring conducted as part of the Northstar Project will provide data to confirm the expected effects from construction of the island and pipeline (Section 11.10.3). Because the reasonably foreseeable future projects are expected to be several miles apart and will not be installed at the same time, cumulative effects associated with combined turbidity plumes are not expected to occur.

Operational discharges from exploration and production facilities are not expected to result in cumulative impacts because these effects are localized (USDOI, MMS, 1998:IV-G-1). Analysis conducted as part of the Environmental Protection Agency's National Pollutant Discharge Elimination System review process concluded that impacts to marine water quality as a result of direct discharges from the Northstar Project into the marine environment will be negligible (Appendix O). In addition, BPXA intends to utilize an Underground Injection Control well for underground disposal of drilling muds and all other non-hazardous wastes, as well as surface runoff and domestic/sanitary wastewater (Appendix N). As a result, the project's operational discharges would have limited and very localized effects.

No significant impacts to sea ice were identified in connection with the Northstar project (Section 5.6.2). The only minor impact identified was associated with an oil spill contacting sea ice; all other impacts on sea ice by the project were negligible. Given the spacial separation of reasonably foreseeable future projects, cumulative effects on sea ice is expected to be negligible.

10.5 CUMULATIVE EFFECTS TO THE BIOLOGICAL ENVIRONMENT

Several potential biological issues were investigated concerning cumulative and project-related impacts. As addressed in the project-specific impacts analysis, issues of concern include: plankton and marine invertebrates, marine and freshwater fish, marine mammals, coastal vegetation and invertebrates, birds, terrestrial mammals, and threatened and endangered species. Potential cumulative impacts related to these topics are discussed below.

10.5.1 Plankton and Marine Invertebrates

Project-related impacts to plankton and marine invertebrates would be negligible to minor, and are associated with direct burial and water column turbidity associated with project construction and maintenance (Section 6.3.2.2). The effects of individual impacts associated with reasonably foreseeable future actions would be similar to those associated with the proposed project. As with the Northstar Project, these effects would be localized and temporary. No measurable overlapping or additive effect on plankton and marine invertebrates caused by the Northstar Project and other reasonably foreseeable future

actions is expected.

10.5.2 Marine and Freshwater Fish

No significant direct impacts to marine or freshwater fish are expected to result from the Northstar Project. Minor impacts to marine fish are expected to result from turbidity and dewatering discharges associated with project construction and operational maintenance. No impacts to freshwater fish are expected from drawdown of freshwater lakes and rivers that are permitted for use as water sources for ice road construction. Total volume of water is restricted as a condition of a state water-use permit. These effects would be localized and temporary, and are not expected to result in measurable overlapping or additive effects in combination with other reasonably foreseeable future actions. Cumulatively, the impacts to fish would be similar to those described in Section 6.4.2.2 and are not expected to result in any significant impacts.

10.5.3 Marine Mammals

Cumulative effects associated with noise impacts on migrating bowhead whales could occur, and are discussed in Section 10.5.7.

Noise-related disturbances associated with Northstar Project construction and operation could displace bearded seals and ringed seals, and may attract polar bears to the island site (Section 6.5.2). Similar effects could result from other foreseeable future offshore developments, but these effects would be localized and would not result in overlapping or additive impacts.

The Southern Beaufort Sea polar bear population has been subjected to disturbance from past and existing oil industry activities in the Alaskan Beaufort Sea, mainly associated with noise disturbance. Noise disturbance can cause avoidance and loss of denning habitat. Mortality from human-polar bear encounters overall has been very low (one bear killed in 25 years of exploration and production in Alaska [S. Amstrup - Pers. Comm., 1998:1]), and future activities are expected to result in only a small increase in mortality to polar bears. However, any small increase in mortality could result in a minor reduction in the subsistence harvest (USDOI, MMS, 1997:IV-G-17). However, future actions, in combination with past and present activities, could result in displacement of polar bears due to noise disturbance. This disturbance would be associated with seismic activity; ice roads; ice road construction; facilities construction, operation, and maintenance; icebreaking barges; gravel mine sites; offshore drilling rigs and islands, and could be significant. The incremental contribution from the Northstar Project is expected to be minor.

Cumulative disturbances associated with past and existing offshore oil and gas activities has had little impact on ringed seals. However, future actions, in combination with past and present activities, could be expected to result in displacement of ringed seals due to noise disturbance. This disturbance would be associated with seismic activity; ice road construction; facilities construction, operation, and maintenance; icebreaking barges; and offshore drilling rigs and islands, and could be significant. The incremental contribution from the Northstar Project is expected to be minor.

10.5.4 Coastal Vegetation and Invertebrates

With the exception of a large oil spill, no significant impacts to coastal vegetation and invertebrates would result from the Northstar Project (Section 6.6.2). Minor impacts could result from tundra removal associated with the installation of gravel pads and vertical support members required for the Northstar Project. The Northstar Project (Alternatives 2, 3, 4, or 5) would result in a net loss of less than 2 acres (0.8 hectares) of tundra as a result of vertical support member placement and gravel pad construction (Section 6.6.2.2). Approximately 14 square miles (36.3 km^2) of tundra have been directly disturbed by previous onshore oil and gas activities on the North Slope (Franklin - Pers. Comm., 1998:1). Therefore, the cumulative amount of tundra loss as a result of the Northstar Project, although measurable, would be small when compared to previously disturbed acreage. Each new development, which would have onshore requirements, would also likely result in a net loss of riverine and tundra habitat associated with installation of onshore pipelines, gravel mining, and construction of gravel pads. This loss would vary depending upon the size, location, and complexity of future development/production activities.

Most of the tundra habitats described above are classified as wetlands as defined by the regulatory program for Section 404 of the Clean Water Act. The development of reasonably foreseeable future projects would result in additional disturbances to wetland habitats. Disturbances associated with individual offshore projects are expected to be similar to the Northstar Project, and onshore projects (such as the Alpine proposal) may disturb up to 100 acres (40.5 hectares). The cumulative area of potential disturbance associated with all currently identified discoveries would represent a small portion of the total wetland habitat in the cumulative impact area. Losses of wetland habitat associated with past development are substantial in certain areas, such as Deadhorse. As stated above, the Northstar Project contribution to this cumulative effect would be minor, and overall the loss of wetlands in the cumulative impact area is not significant. The Northstar Project design incorporates the placement of a gravel mine on a sparsely vegetated river bar area, which minimizes the adverse effect of this project feature. Following completion of gravel extraction activities, this area will remain as an open water lake which could provide a beneficial fish overwintering habitat.

10.5.5 Birds

Impacts to migratory birds (sea ducks) due to offshore helicopter overflights during construction are significant (Section 6.7.2.2). Avoidance or minimization of these impacts would be recommended by USFWS. Minor impacts were identified associated with disturbances to tundra-nesting birds from helicopter overflights, bird mortality associated with bird strikes on offshore structures, and loss of tundra wetland habitat. Impacts associated with attraction to a new food source at Seal Island include a minor increase in abundance of predatory bird species, which in combination with other artificial food sources from existing and reasonably foreseeable future actions, could result in a cumulative effect on tundra nesting birds. Cumulative effects associated with other disturbances are discussed below.

Helicopter overflights associated with routine pipeline inspections, island operations, and access for pipeline repair during the breeding season could result in displacement of birds from nests or interruption

of feeding/brood-rearing activity. Disturbances from helicopter activity associated with the Northstar Project in combination with other reasonably foreseeable future actions, especially activities in Simpson Lagoon, the Gwydyr Bay and Point Storkersen area, and other offshore projects (such as Sandpiper), are presumed to be a significant cumulative effect (E. Taylor - Pers. Comm., 1998:1). These impacts would be most substantial if flight paths cross the Simpson Lagoon area or follow the shorelines of the barrier islands. Brant at nesting colonies or brood-rearing areas are the most likely affected species, and adverse effects could also occur to molting oldsquaw and common eiders in the lagoons. These cumulative impacts could be reduced to minor levels by prohibiting low-level helicopter flight over concentrations of sensitive species during critical time periods.

Bird strikes on offshore structures during periods of fog could result in the loss of individual birds. Although the number of birds potentially affected by this impact cannot be estimated using presently available data, these numbers would likely increase as additional offshore structures are developed. Because the combination of all reasonably foreseeable future actions involving new offshore structures represents a very small portion of the cumulative offshore impact area, the likelihood of this impact affecting a substantial proportion of any bird population is expected to be extremely small. This cumulative effect is not expected to be significant.

The construction of existing oil field facilities in the Prudhoe Bay - Kuparuk area is estimated to have directly affected over 58 square miles (150 km^2) of prime waterfowl wetland habitat, including the destruction of over 14 square miles (36.3 km^2) of this habitat. Cumulative habitat losses could affect the nesting distribution or density of some species for more than one generation. The planned construction of BPXA's proposed project (Alternative 2) during winter, and installation of a pipeline on vertical support members without new gravel roadway development, will result in a minor contribution to this cumulative effect (less than 2 acres [0.8 hectares]). Alternatives 3, 4, and 5 would result in a lesser contribution to this cumulative effect by routing onshore pipelines in existing disturbed corridors for most of their length.

10.5.6 Terrestrial Mammals

No significant impacts to terrestrial mammals are expected to result from the construction and operation of the Northstar Project (Section 6.8.2). Minor impacts to Arctic fox could occur as a result of vehicle collisions on project ice roads, attraction to construction areas, and disturbance from occasional low-level helicopter overflights associated with operations. Helicopter overflights could also result in temporary displacements of caribou and grizzly bear. Northstar facilities could also result in minor impacts to caribou insect-relief movement during summer. Disturbances to the Arctic fox are expected to be localized and very limited, and cumulative impacts are not expected to result in substantial additive or overlapping effects. Similarly, cumulative disturbances to grizzly bear associated with low-level helicopter overflights are expected to be infrequent and localized, since low-level flights are generally restricted by conditions applied to project approvals.

Concerns regarding potential disruption of caribou movements have led to the development of several measures intended to reduce impact to the species. The Northstar Project has incorporated these design elements, and other foreseeable future actions are expected to do likewise. These features include

elevation of onshore pipelines at least 5 ft (1.5 m) above the ground and minimizing the construction of permanent roads alongside pipelines. The Northstar pipeline landfall valve station is well inland of the coast (150 ft [46 m]). This provides caribou an unimpeded movement corridor at the coastline. It is reasonable to expect that these measures will also be applied to future projects, and the resulting cumulative impacts to caribou will be minor.

10.5.7 Threatened and Endangered Species

Four threatened or endangered species occur in or near the Northstar Project area: delisted Arctic peregrine falcon, threatened Steller's eider, threatened spectacled eider, and endangered bowhead whale (Section 6.9.1). No Arctic peregrine falcon nesting sites are known to occur in the vicinity of the Northstar facilities, and disturbances associated with project activities (including noise) are not expected to adversely affect this species (Section 6.9.2.2). The Northstar Project would not contribute to any adverse cumulative effects to the Arctic peregrine falcon.

Among the purposes of the ESA are to conserve ecosystems on which listed 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.

Only one Steller's eider nest site is known to occur in the Northstar Project area. Impacts to Steller's eiders associated with cumulative project activity is not expected. Spectacled eiders are known to nest within 0.5 miles (0.8 km) of the Northstar pipeline routes (TERA, 1995: 7-9 and Appendix 2) and two or more nest sites could be affected by helicopter overflights along the pipeline route. This species appears to be somewhat tolerant of noisy human activities (TERA, 1995: 14; TERA, 1996: 9); however, there is a potential for adverse noise disturbance impacts from low-level helicopter overflights. Because this species has exhibited declining populations in recent years, an extra measure of protection is required under the ESA and measures to avoid or minimize impacts have been suggested by the USFWS. The USFWS has evaluated the potential project and cumulative impacts on spectacled and Steller's eiders in its Biological Opinion (Appendix M). The USFWS will recommend that helicopter flight corridors not cross breeding habitat from June through August to avoid or minimize potential effects.

Cumulative effects to the bowhead whale could be caused by regional increases in offshore oil and gas activity. Other than potential oil spill effects (Section 10.7), impacts associated with offshore oil and gas activities are primarily from noise generated during facilities construction, drilling, operations, and seismic surveys. Bowhead whales exhibit avoidance behavior in the vicinity of vessels, seismic survey activity, and aircraft at altitudes below 984 ft (300 m). Observations vary of bowhead response to disturbances, and the typical response to a single disturbance is avoidance behavior involving movements of up to a few miles. Recorded avoidance movements last a few minutes in the case of vessel and aircraft noise, and up to 30 to 60 minutes in response to seismic survey activity (USDOI, MMS, 1997: IV-CJ-21).

Cumulative offshore activity associated with current and reasonably foreseeable future projects could

represent substantial increases above current levels. Seismic survey activities associated with leases issued in recent and currently planned federal lease sales could introduce substantial new noise-related disturbances. Because the bowhead are typically found in offshore waters during the open water months when these activities occur, any such activities would be expected to directly affect the bowhead. If multiple disturbances were to occur at several offshore locations over multiple years coincident with the fall bowhead migration, the reaction of the species could result in a migratory path deflection, either temporary or long lasting. This effect can be eliminated or substantially reduced by coordination of the timing and location of seismic activities and offshore facility access vessel and helicopter paths to minimize operations in the vicinity of migrating whales. Such mitigation measures have been proposed and are presented in Section 11.10.2.

Although the potential migratory path deflection would not likely represent an adverse effect on bowhead populations, it could result in a significant impact to subsistence whaling. This topic is discussed in Section 10.6.1.

NMFS has reviewed the current status of the bowhead whale population (the environmental baseline for the project area), the potential effects of the Northstar Project, and its cumulative effects, and concluded that the activity will not jeopardize this population. For more information, see NMFS's Biological Opinion (Appendix M).

10.6 CUMULATIVE EFFECTS TO THE HUMAN ENVIRONMENT

Cumulative effects on the human environment are expected to affect subsistence, land and water use, socioeconomics, and visual/aesthetic resources. As discussed in Sections 7.4.5 and 7.9.2.2, the Northstar Project is not expected to contribute to cumulative effects on living cultural resources. Expected cumulative effects and Northstar Project contributions are discussed below.

10.6.1 Subsistence

Subsistence activities potentially affected by existing and reasonably foreseeable future projects include onshore hunting of terrestrial mammals and waterfowl, and offshore harvesting of bowhead whales and other marine mammals (Section 7.3.2). The geographic expansion of industrial activity and development in both onshore and offshore areas could have significant effects on local communities, as discussed below.

Traditionally, all access for subsistence hunting has been restricted in the oil fields for security and safety reasons. Recently, ARCO has agreed to permit access at its Alpine and Tarn developments for subsistence hunting and fishing purposes, with the exception of reasonable security and safety procedures. Such mutual agreements between the oil companies and Native subsistence users would mitigate local adverse and cumulative impacts on subsistence, and similar agreements may be reached in the NPRA and elsewhere along the North Slope in the future. Specifically related to the Northstar Project, onshore facilities for Alternatives 2 and 3 would have negligible adverse cumulative effects on subsistence hunting and game availability. Onshore facilities for Alternatives 4 and 5 are not expected to contribute to any

new cumulative adverse effects to subsistence hunting and game availability, since these routes lie within areas that have already been restricted.

Subsistence whaling is expected to experience adverse cumulative effects. These effects are associated with the bowhead whale's avoidance response to noise and activity. As discussed in Section 10.5.7, seismic survey activities and foreseeable future offshore exploration and development could create multiple offshore noise disturbances extending over a broad geographic area. The principal concern regarding this cumulative disturbance is the possibility that migrating whales avoiding multiple noise disturbances could alter their migration route to a location further offshore. If such an effect was to occur, this could significantly affect whaling communities in the cumulative impact area, including Barrow, Nuiqsut, and Kaktovik. The unavoidable and non-mitigable noise which will be generated by the Northstar production island facilities and associated contractor and operational activities are not predicted to cause significant disturbance of bowhead whales or the bowhead whale subsistence harvest (Section 9.8.2 and 6.9.2.2). As noted in Section 11.10.2, monitoring of the noise signature of the Northstar production island and related activities is a mitigation measure which will be considered and likely adopted by responsible agencies as a means of verifying the absence of any significant effect. While it is likely any additional offshore production islands of similar design proposed in the future will have a comparable noise signature, the cooperating agencies recognize that a primary public concern regarding offshore cumulative impacts is the potential for multiple developments. To deflect the bowhead migration path and reduce subsistence harvest success.

The potential for future developments to cause or contribute to any deflection of the migration or impact the harvest will depend largely upon the proposed location with respect to the traditional migratory path and traditional harvest areas. Accordingly, proposed future projects will have to be analyzed on a case-by-case basis to determine whether and how they may cause or contribute to any effects on the bowhead migration or subsistence harvest. It must also be recognized that periodic and predictable offshore seismic operations have the potential alone to disrupt the whale migration and subsistence harvest, if not restricted in time and location (Section 9.5.1.1). Conducting a seismic operation during the fall bowhead migration near subsistence harvest areas in proximity to the Northstar production island could compound the minor impact of the island. Timing and location restrictions of any seismic operations proposed during Northstar construction and operations could eliminate or minimize these potential adverse cumulative effects.

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. Although it is impossible to predict whether North Slope residents would support future oil development, the other reasons stated in Section 7.10 suggest that potential adverse cumulative effects on North Slope Inupiat would not be, on balance, disproportionately high.

10.6.2 Land Use

The projected development of onshore areas associated with the reasonably foreseeable future projects (Alpine and Tarn) have been rezoned. North Slope Borough (NSB) land management regulations include

several policies regarding project design, seasonal restrictions, and protection of other land uses that are intended to minimize environmental effects (Section 7.5.1). Application of these regulations is expected to reduce impacts associated with individual projects that might otherwise combine to create cumulative effects.

One cumulative land use impact that would not be avoided is the geographic expansion of industrial uses beyond the existing developed Prudhoe Bay - Kuparuk area. This represents a cumulative, large-scale change in the designated land use of this area. Northstar Project onshore facilities associated with Alternative 2 are not located within the existing developed area. This alternative would contribute to the geographic expansion of industrial land uses, and would represent a minor contribution to cumulative impacts to onshore land use. Other Northstar Project alternatives would not contribute to this cumulative impact.

Reasonably foreseeable development of offshore areas includes the Liberty prospect. Subsea pipelines built through state waters would involve the rezoning of land and waters currently zoned as a Conservation District to a Resource Development District. This rezoning would require a revision to the approved Master Plan for the area and review for compliance with the NSB Coastal Management Plan. Therefore, this would have a cumulative impact on the existing onshore Resource Development Area, thereby extending this land use to a Conservation District not presently utilized in this manner. However, this cumulative effect would be minor due to limited actual use of the seafloor by industry.

In addition, the project could represent the first of several developments between existing Prudhoe Bay and Kuparuk area developments. The presence of a pipeline landfall at Point Storkersen associated with Alternatives 2 and 3 could facilitate potential future Gwydyr Bay development, and allow consolidation of potential future Gwydyr Bay development by establishing an accessible common carrier pipeline in proximity to this area. The development of the Gwydyr Bay area would result in an industrial expansion into a presently undeveloped area. It is not presently known whether Gwydyr Bay development economics would be substantially affected by the presence of the Northstar pipeline facilities. Gwydyr Bay area development would represent a substantial land use change, and Northstar's Alternative 2 would contribute to this cumulative effect by establishing a pipeline corridor through this area.

The cumulative offshore land and water use impact that is reasonably foreseeable is the geographic expansion of industrial uses to offshore areas north of the barrier islands. Successful permitting, development, and production of the Northstar Project could contribute to development of other offshore projects. However, because other existing uses of this offshore area are minor, the cumulative impact to land use would be minor.

10.6.3 Visual Resources/Aesthetics

Existing development in the Prudhoe Bay-Kuparuk area has substantially altered the visual character of this area. The presence of industrial structures in an otherwise undeveloped area and introduction of artificial lighting over broad areas where none previously existed are generally perceived as adverse effects of existing North Slope development. Reasonably foreseeable future projects will result in the

geographic expansion of these visual effects. The Northstar Project would contribute to the expansion of geographic effects of artificial lighting by adding a light source in offshore waters and short-term lighting at the gravel mine site (Section 7.8.2.2). The onshore pipeline route specified in Alternative 2 would contribute to the cumulative visual impact of the Prudhoe Bay development area. Other action alternatives would lessen this effect by routing onshore pipelines primarily along existing disturbed areas. The Northstar Project would represent a minor contribution to the visual existing cumulative impacts in the Prudhoe Bay area.

10.6.4 Socioeconomics

Existing and reasonably foreseeable future projects are expected to reduce the rate of decline of State of Alaska revenues associated with North Slope oil production. As discussed in Section 10.3.3, the 1995 North Slope oil production rate of 1.45 million barrels/day is expected to decline to 0.292 million barrels/day by the year 2020. A similar decline in revenues to the NSB and local villages would be a reasonable expectation. The Bureau of Land Management (BLM) estimates total production from existing development and known fields could be 6.47 billion barrels from 1996 to 2020 (USDOI, BLM, 1998:IV-A-43-46). The BLM estimates that up to 1.22 billion barrels could be produced from resources on existing and proposed federal leases, most of which have not yet been discovered. Although these production rates would still result in a net decline in oil production, they would partially offset state revenue declines. This represents a substantial beneficial impact on State of Alaska revenues, since North Slope oil and gas revenues represent the primary source of state revenues (ADNR, 1997:5-40) (Section 7.6). The Northstar Project would represent approximately 2.4%of the total currently projected North Slope oil production during its project life.

Cultural values of Native communities along the North Slope could be affected by changes in population, social organization and demographic conditions, economy, and alterations of the subsistence cycle. While subsistence is the core value and central feature of Inupiat culture, a trend toward displacement of the community social institutions could lead to a short-term decreased emphasis on other values, such as the importance of the family, cooperation, and sharing. Increasing offshore oil development activity, when combined with the increasing encroachment of onshore development, could increase access to urban communities and cause more interaction with oil-industry workers, resulting in the introduction of new values and ideas, as well as increased racial tensions. Tensions could be created and could result in increased incidents of socially maladaptive behavior and family stress, potentially straining the traditional Inupiat institutions' abilities to maintain social stability and cultural continuity.

Long-term change depends on the relative weakening of traditional stabilizing institutions through prolonged stress and disruptive effects that could be exacerbated by activities associated with the Northstar Project. These changes already are occurring to some degree on the North Slope as a result of the cumulative effects of onshore oil and gas development, more dependence on a wage economy, higher levels of education, improved technology, improved housing and community facilities, improved infrastructures, increased presence of non-Natives, increased travel outside of the North Slope, and the introduction of television and the Internet. Generally, NSB institutions, such as the school district that promotes teaching Inupiat language and culture, the Alaska Eskimo Whaling Commission that negotiates

with industry to protect subsistence whaling interest, the Borough Department of Wildlife Management, and other regional and village Native corporations and organizations, work vigorously and quite successfully at preventing any weakening of traditional cultural institutions and practices.

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. Although it is impossible to predict whether North Slope residents would support future oil development, the other reasons stated in Section 7.10 suggest that potential adverse cumulative effects on North Slope Inupiat would not be, on balance, disproportionately high.

10.7 CUMULATIVE EFFECTS OF OIL SPILLS

A large oil spill could have significant impacts on several resources in the project area. These impacts were discussed in Chapters 5, 6, and 7 and include: contamination of soils, sediments, and surface water bodies (Section 5.3.2), mortality to polar bears, birds, and freshwater invertebrates (Sections 6.5.2, 6.6.2, and 6.7.2), damage to coastal vegetation during the spill response (Section 6.6.2), and injury/mortality to bowhead whales (Section 6.9.2). Such an oil spill could also have significant impacts to subsistence activities (Section 7.3.2 and 9.8.2), cultural and archaeological resources (Section 7.4.5), and North Slope socioeconomics (section 7.6.2). In addition to potential significant impacts to individual resources by an oil spill, the Northstar Project contributes to the cumulative risk of oil spill occurrence associated with existing North Slope development and additional future development expected to occur. The BLM has estimated that existing developments and expected new developments will result in a total production of 6.47 billion barrels of oil from 1997 to 2020 (USDOI, BLM, 1998: IV-A-43-46). As will be shown in this section, this production rate would result in a cumulative probability of one or more major oil spills (greater than 1,000 barrels) of 95.2% over the entire period of 1997 to 2020. Comparable cumulative spill probability over the same 23-year period in the absence of the Northstar Project would be 93.7%.

These probabilities were calculated using the MMS OCS spill history statistics discussed in Chapter 8. These calculations are based on actual North Slope oil spill occurrence observations for all existing operations, and for all proposed onshore production operations and related pipelines. Because offshore production facilities and subsea pipelines have not yet been developed on the North Slope, the MMS oil spill occurrence rates based on Gulf of Mexico data were used to calculate spill rates and related probabilities associated with future offshore development. Although these rates appear to be substantially higher than observed North Slope onshore spill rates, and may over-estimate the actual spill risk, no statistical data directly applicable to arctic offshore production facilities and subsea pipelines are currently available. Expected oil production rates from individual development activities were determined by proportionally adjusting the 6.47 billion barrel projection using the oil reserve estimates in Table 10-3 associated with expected and possible future production. Tables 10-4 and 10-5 present the production rates associated with different development features, and calculated cumulative statistically expected number of spills. Table 10-6 presents oil spill probabilities calculated using this information.

In addition to concerns regarding the cumulative risk of an oil spill, comments from the public related to potential cumulative effects expressed a concern that multiple oil spills could result in cumulative

impacts. To fully evaluate this concern, an understanding of the likelihood of multiple spills is necessary.

The potential for two or more spills within a 5-year period was evaluated to address a time period which is expected to result in additive effects caused by a second disturbance to resources which have not fully recovered from the initial oil spill. Multiple spill probabilities were calculated assuming a total 5-year production of 1.425 billion barrels of oil (based on 22% of the expected production of 6.47 billion barrels from 1997 to 2020), and approximately 0.053 billion barrels of oil production from the Northstar Project (33% of total Northstar production). Based on these assumptions, the cumulative probability of two or more major spills during a 5-year period (including Northstar) is 15.4%. Without the contribution of the Northstar Project, the cumulative probability of multiple spills within a 5-year period is 12.2%. Table 10-7 presents details associated with the determination of these probabilities. These cumulative probabilities include both onshore and offshore spills, and multiple spills would not necessarily affect the same resources.

Multiple spills could adversely affect biological resources if subsequent disturbances occur while populations are still recovering from an earlier disturbance. This effect is of greatest concern with regard to species with limited or declining numbers of individuals, such as: spectacled eider, Steller's eider, common eider, oldsquaw, and King eider. This potential for additive effects is also a concern with regard to threatened and endangered species and subsistence species, such as the bowhead whale. As indicated by the results in Table 10-7, the likelihood of two or more spills within time frames likely to result in overlapping effects is relatively low (about 15.4%). This probability would change very little (12.2%) in the absence of the Northstar Project.

Table 10-4 (page 1 of 1)

Table 10-5 (page 1 of 1)

Table 10-6 (page 1 of 1)

Table 10-7 (page 1 of 1)

As indicated above, the cumulative likelihood of two or more major spills within a 5-year period is 15.4%. The occurrence of multiple spills and resulting multiple disturbance of the same resources would be even more unlikely. However, if this did occur, the effects could be substantial. Impacts would be most severe with respect to populations that are already declining, such as spectacled eiders.

As stated previously, the overall likelihood of multiple spills within a 5-year period is relatively small, and the Northstar contribution to this probability is minor.

Oil spills could affect subsistence hunting of polar bears in several ways. In the event of direct mortality caused by ingestion of contaminated food (such as oiled ringed seals) or mortality associated with reduced food availability, reductions in the allowable subsistence harvest could be implemented. Spill response and cleanup activities could also conflict with access and hunting activity during hunting periods. These effects are most likely to occur as a result of a single spill, since overlapping effects caused by multiple spills within relatively short time-frames (5 years) are considered unlikely as explained above.

Small oil spills are likely to occur with or without the development of the identified reasonably foreseeable future projects. In the MMS analysis conducted for Lease Sale 170, it is estimated that 287 to 571 small releases are statistically expected to occur over the 30-year time frame addressed by their study. The MMS analysis estimates a total release volume of 3,295 to 6,420 barrels from all releases combined (an average per spill release of 11.5 barrels). The MMS concluded that these small releases would result in localized water quality impacts, and that cumulative effects would not be significant (USDOI, MMS, 1998: IV-G-2-5). The Northstar Project represents a contribution of less than 2% of the total oil production considered by the MMS in determining these chronic oil spill volumes.

10.8 CUMULATIVE EFFECTS OF NOISE

Disturbance impacts resulting from helicopter overfllight during construction could have significant impacts on molting oldsquaw and common eiders. Significant impacts to subsistence harvesting of the bowhead whale could occur if construction or operation noise/activities coincided with the fall migration period and resulted in a reduced harvest. These impacts were discussed in Section 9.8.2.

Existing and reasonably foreseeable future projects are located across a broad geographic area, and additive effects of noise associated with onshore facility operations are not expected. Potential cumulative noise effects could result from multiple offshore noise sources and activity and related effects on bowhead whale migration. Use of common or overlapping helicopter transport corridors by multiple projects could startle sensitive bird species.

As discussed in Sections 10.5.7 and 10.6.1, offshore seismic survey activities and future offshore development could create multiple offshore noise disturbances extending over a broad geographic area. The principal concern regarding this cumulative disturbance is the possibility that migrating bowhead whales would respond to these disturbances by altering their migration route to a location further offshore. Multiple project locations and survey sites could result in multiple avoidance responses by

migrating whales. As the whales experience increasing numbers of disturbances, it has been hypothesized that they may adopt a migration route located further offshore, rather than a meandering route based on multiple disturbance responses. If such an effect was to occur, this could significantly affect whaling communities beyond the cumulative impact area, including Barrow, Nuiqsut, and Kaktovik. The combined effect described has not been documented by scientific studies, and is only a hypothesis at present. Measures that could be implemented to reduce the potential for such a cumulative effect include: prohibition of seismic survey activities during bowhead whale migration periods; coordination of helicopter activities to establish minimum transit altitudes and to minimize the length of overwater transit routes to offshore sites during the fall whale migration; prohibition of fall icebreaking barge activities prior to October 15; and coordination of vessel activity during the whale migration period to minimize the length of offshore transit routes. These requirements could be relaxed during other portions of the year.

Helicopter activities from multiple projects in common or overlapping travel corridors could create combined or repeated noise disturbances that could be significant. Of particular concern is the potential for combined helicopter activities of the Northstar Project, other future activities in the Gwydyr Bay/Point Storkersen area, and future offshore developments such as Sandpiper. Helicopter overflights of the Northstar Alternative 2 pipeline route and Simpson Lagoon area could displace birds from nests and interrupt feeding, staging, and molting activities. Brant are the most likely affected species, although adverse effects to spectacled eiders, oldsquaw, common eiders, and other birds could also occur. Those impacts could be effectively reduced by restricting flight paths to avoid sensitive nesting areas (particularly spectacled eider breeding areas) during active breeding and brood-rearing periods (June through August), and establishing minimum helicopter flight altitudes to reduce ground-level noise.

10.9 REFERENCES

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TABLE 10-1
EXISTING OIL AND GAS DEVELOPMENT, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production (Year)	1996 Oil Production (MMBBL)	Estimated Remaining Reserves (end of 1996) (MMBBL)	Facilities								
				Disturbed Area (Roads, Pads, & Airstrips) (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines		Reserve Pits		Wells (No.)	Pads/ Platforms (No.)
							(No.)	(Acres)	(No.)	(Acres)		
Duck Island												
Endicott	1987	27.663	258	392	15	29	1	179	0	0	105	2
Sag Delta N.	1989	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Sag Delta	1989	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
Prudhoe Bay												
Prudhoe Bay	1977	312.609	3,443	4,590	200	145	6	726	106	560	1,256	38
Lisburne	1981	5.139	57	213	18	50	--	--	10	16	81	5
Niakuk	1994	11.045	90	22	--	5	--	--	--	--	18	--
West Beach	1994	0.499	30	--	--	--	--	--	--	--	1	--
N. Prudhoe Bay	1993	0.129	75	--	--	--	--	--	--	--	1	--
Pt. McIntyre	1993	58.751	312	33	--	12	--	--	--	--	47	--
Kuparuk												
Kuparuk	1981	99.459	1,275	1,435	94	134	5	564	126	161	835	34
West Sak	1998	--	279	--	--	--	0	0	--	--	50	--
Milne Point												
Milne Point	1985	12.686	210	205	19	40	1	43	--	--	110	4
Cascade	1996	--	50	31	--	--	--	--	--	--	--	--
Schrader Bluff	1991	1.068	281	--	--	--	--	--	--	--	22	--
Sag River	1994	0.346	19	--	--	--	--	--	--	--	3	--
NPRA												
East Barrow	1981	--[3]	--[3]	--	--	--	--	--	--	--	--	--
South Barrow	1950	--[3]	--[3]	--	--	--	--	--	--	--	--	--
Walakpa	1993	--[3]	--[3]	--	--	--	--	--	--	--	--	--
Badami												
Badami	1998	--	120	85	4.5	35	1	89	0	0	50	2
Tarn												
Tarn	1998	--	50	73	10	10	1	--	0	0	40	2

Notes: 1 = Information in this table was developed from USDOI, BLM, 1998: IV-A-44-45. The cumulative development area and existing developments are shown on Figure 10-2.
2 = Included in Endicott details
3 = These developments produce natural gas, and do not contribute oil production to North Slope oil transportation facilities
-- = Not applicable
MMBBL = Million barrels
No. = Number
NPRA = National Petroleum Reserve, Alaska

TABLE 10-2
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities								
				Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines		Reserve Pits		Wells (No.)	Pads/ Platforms (No.)
							(No.)	(Acres)	(No.)	(Acres)		
Currently Proposed Projects												
Northstar	2001	158	Development Drilling & Production (active proposals currently under consideration)	20	0	28	1	36	0	0	23	1
Alpine	2000	250-300	Development Drilling & Production (active project currently under development)	97	3	34	0	0	0	0	150	2
Liberty	Before 2015	120	Development Drilling & Production (active proposal currently under consideration)	16	0	6	1	45	0	0	23	1
Known Discoveries/Potential Future Projects												
Colville River Fiord	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Kuukpik Kalubik	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Colville Delta	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Point Thomson Sourdough	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Pt. Thomson	Before 2015	200-300	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Flaxman 1	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Gwydyr Bay Gwydyr Bay	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Mikkelson	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Yukon Gold	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Pete's Wicked	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]

TABLE 10-2 (Cont.)
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities								
				Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines (No.)	Gravel Mines (Acres)	Reserve Pits (No.)	Reserve Pits (Acres)	Wells (No.)	Pads/ Platforms (No.)
Known discoveries/Potential Future Projects (Cont.)												
Sandpiper	Before 2015	--[3]	Three delineation wells planned for Year 2000. DPP submitted to MMS	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Kuvlum	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Hammerhead	Before 2015	--[3]	Resource Evaluation, Planning, Development (Production after 2010)	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
Lease Sales and Resource Evaluation Areas												
Alaska State Lease Sales No. 87	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells, production facilities	--	--	--	--	--	--	--	--	--
North Slope Areawide	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Beaufort Sea Areawide	--[4]	Moderate to High Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
North Slope Foothills Areawide	--[4]	Moderate Potential	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Federal NPRA Northeast Planning Area	--[4]	130-600	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--
Western Planning Area	--[4]	130-1200	Seismic exploration, exploration and delineation wells	--	--	--	--	--	--	--	--	--

TABLE 10-2 (Cont.)
FORESEEABLE FUTURE ACTIONS, NORTHSTAR PROJECT CUMULATIVE IMPACT AREA[1]

Unit or Area/Field	Initial Production Expected (Year)	Estimated Reserves (MMBBL)	Nature of Activity Expected from 1999 Through 2015	Facilities								
				Disturbed Area[2] (Acres)	Gravel Roads (Miles)	Pipelines (Miles)	Gravel Mines (No.)	Gravel Mines (Acres)	Reserve Pits (No.)	Reserve Pits (Acres)	Wells (No.)	Pads/ Platforms (No.)
Lease Sales and Resource Evaluation Areas (Cont.)												
Federal OCS Lease Sales												
Lease Sale 176	2006	350-670	Seismic exploration, shallow hazards surveys, exploration and delineation wells, production facilities	--	--	96-258	--	--	--	--	87-111	3-5
Lease Sale 176	--[4]	To be determined	Seismic exploration, shallow hazards surveys, exploration and delineation wells	--	--	--	--	--	--	--	--	--

Note: 1 = The cumulative development area and proposed and future projects are shown on Figure 10-2.
2 = Roads, pads and airstrips
3 = Specific reserve estimates and development proposals are not presently available.
4 = No specific projects have been identified and initial production dates cannot be accurately estimated. Most production associated with these lease sales is likely to occur after 2015.

-- = No specific information is currently available.
MMBBL = Million barrels
No. = Number
NPRA = National Petroleum Reserve, Alaska
OCS = Outer Continental Shelf

Source: USDOI, BLM, 1998: IV-A-41-52.

TABLE 10-3
OIL RESERVES AND RESOURCES ESTIMATES,
NORTHSTAR PROJECT CUMULATIVE IMPACT AREA

Activity	Oil Production (MMBBL)
Past Production (Through 1996)	
Onshore	11,230
Offshore	340
Subtotal	11,570
Expected Future Production	
Onshore – existing fields	6,320
Offshore – existing fields	260
Onshore – planned fields	365
Offshore – planned fields	265
Subtotal	7,210
Possible Future Production	
Onshore	1,850
Offshore	460
OCS projects in currently unleased areas	1,200
Subtotal	3,510
Future NPRA Leasing	
Northeast Planning Area	130-600
Western Planning Area	130-1,200
Subtotal	260-1,800
Speculative Future Production	
Onshore	4,000
Offshore	2,000
Subtotal	6,000

Notes: MMBBL = Million barrels
NPRA = National Petroleum Reserve, Alaska
OCS = Outer Continental Shelf

Source: USDOI, BLM, 1998: Tables IV.A.5-4 and IV.A.5-7

TABLE 10-4
CUMULATIVE SPILL RISK (NORTHSTAR INCLUDED)
1997 TO 2020

Development	Production Rate (Bbbl)	Spill Rate (spills/Bbbl)	Data Source	Expected Value (8)
Existing				
Onshore production pads	3.814	0.0599	North Slope [3]	0.2285
Onshore pipelines [1]	3.971	0.086	North Slope	0.5564
Offshore pads	0.157	0.0599	North Slope [3]	0.0094
Subtotal				0.7943
Proposed/New				
Onshore production pads	1.337	0.0599	North Slope [3]	0.0801
Onshore pipelines [1]	2.499	0.086	North Slope	0.2149
Offshore pads	1.162	0.45	MMS	0.5229
Offshore pipelines [2]	1.162	1.32	MMS	1.5338
Subtotal				2.2518
Cumulative, statistically expected value				3.046

Notes:

1 = This entry presents spill risk associated with existing and proposed/new production separately, though some of the new production will be transported through existing onshore pipelines. This is intended to illustrate the contribution of proposed/new development to pipeline spill risk, though some of the pipelines may already exist.

2 = This volume is double-counted in the onshore pipeline total, since all offshore production will ultimately be transported in onshore pipelines. To avoid double counting, the onshore pipeline contribution to the total expected value was reduced by the offshore throughput. For this reason, the total (cumulative) expected value is not the sum of all entries in the expected value column.

3 = This spill rate was calculated based on the observed occurrence of zero large spills (>1,000 bbls) during the history of North Slope oil production. Since 11.57 billion barrels of oil have been produced and no major production pad spills have occurred, this spill rate was computed as the spill rate which results in a 50 percent probability that zero large spills (>1,000 bbls) would be observed with a total production of 11.57 billion barrels.

bbls = Barrels

Bbbl = Billion barrels

TABLE 10-5
CUMULATIVE SPILL RISK WITHOUT NORTHSTAR
1997 TO 2020

Development	Production Rate (Bbbl)	Spill Rate (spills/Bbbl)	Data Source	Expected Value (8)
Existing				
Onshore production pads	3.814	0.0599	North Slope [3]	0.2285
Onshore pipelines [1]	3.971	0.086	North Slope	0.5564
Offshore pads	0.157	0.0599	North Slope [3]	0.0094
Subtotal				0.7943
Proposed/New				
Onshore production pads	1.337	0.0599	North Slope [3]	0.0801
Onshore pipelines [1]	2.341	0.086	North Slope	0.2013
Offshore pads	1.004	0.45	MMS	0.4518
Offshore pipelines [2]	1.004	1.32	MMS	1.3253
Subtotal				1.9722
Cumulative, statistically expected value				2.767

Notes:

1 = This entry presents spill risk associated with existing and proposed/new production separately, though some of the new production will be transported through existing onshore pipelines. This is intended to illustrate the contribution of proposed/new development to pipeline spill risk, though some of the pipelines may already exist.

2 = This volume is double-counted in the onshore pipeline total, since all offshore production will ultimately be transported in onshore pipelines. To avoid double counting, the onshore pipeline contribution to the total expected value was reduced by the offshore throughput. For this reason, the total (cumulative) expected value is not the sum of all entries in the expected value column.

3 = This spill rate was calculated based on the observed occurrence of zero large spills (>1,000 bbls) during the history of North Slope oil production. Since 11.57 billion barrels of oil have been produced and no major production pad spills have occurred, this spill rate was computed as the spill rate which results in a 50 percent probability that zero large spills (>1,000 bbls) would be observed with a total production of 11.57 billion barrels.

bbls = Barrels

Bbbl = Billion barrels

TABLE 10-6
CUMULATIVE OIL SPILL PROBABILITIES (ONE OR MORE SPILLS)
1997 TO 2020

Development	Cumulative Probability Without Northstar		Cumulative Probability With Northstar	
	Expected Value (8)	Probability 1 or more spills >1,000 bbl	Expected Value (8)	Probability 1 or more spills > 1,000 bbl
Existing Development				
Onshore spills	0.7849	54.5%	0.7849	54.4%
Offshore spills	0.0094	0.9%	0.0094	0.9%
Subtotal - Existing	0.7943	54.8%	0.7943	54.8%
Proposed/New Development				
Onshore spills	0.2814	24.5%	0.2950	25.5%
Offshore spills	1.7771	83.1%	2.0567	87.2%
Subtotal - Proposed/New	1.9722	86.1%	2.2518	89.5%
Cumulative Probability	2.767	93.7%	3.046	95.2%

Notes: > = Greater than
bbl = Barrels
% = Percent

TABLE 10-7
CUMULATIVE PROBABILITY OF MULTIPLE SPILLS
WITHIN A 5-YEAR PERIOD [1]

Development	Cumulative Probability Without Northstar			Cumulative Probability With Northstar		
	5-Year Production (Bbbl)	Expected Value (8)	Probability of 2 or more spills >1,000 bbl	5-Year Production (Bbbl)	Expected Value (8)	Probability of 2 or more spills >1,000 bbl
Existing Development						
Onshore spills	0.829	0.1706	1.3%	0.829	0.1706	1.3%
Offshore spills	0.034	0.0020	0.0%	0.034	0.0020	0.0%
Subtotal – Existing		0.1727	1.3%		0.1727	1.3%
Proposed/New Development						
Onshore spills	0.291	0.0612	0.2%	0.291	0.0658	0.2%
Offshore spills	0.218	0.3859	5.8%	0.271	0.4797	8.4%
Subtotal – Proposed/New		0.4283	6.9%		0.5221	9.7%
Cumulative Probability		0.6010	12.2%		0.6948	15.4%

Notes: 1 = Total production within a 5-year period is computed as 21.74% of the total production projected for the period 1997 to 2020. Total Northstar production over a 5-year period is estimated as 33.3% of the 158-million barrel total Northstar production, as 52.7 million barrels.
bbl = Barrels
% = Percent
> = Greater than
Bbbl = Billion barrels