Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

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Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Until leases are sold and discoveries are made, DO&G cannot predict when any oil and gas activity might occur or the type, location, duration, or level of those potential activities. In addition, methods to explore for, develop, produce, and transport petroleum resources will vary depending on the area, lessee, operator, and discovery. Best interest findings are not required to speculate about such possible future effects (AS 38.05.035).

However, AS 38.05.035(g) specifies that the following shall be considered and discussed in a best interest finding: reasonably foreseeable cumulative effects of exploration, development, production, and transportation for oil and gas on the lease sale area, including effects on subsistence uses, fish and wildlife habitats and populations and their uses, and historic and cultural resources; reasonably foreseeable fiscal effects of the lease sale on the state and affected municipalities and communities; and reasonably foreseeable effects of exploration, development, production, and transportation for oil and gas on municipalities and communities within or adjacent to the lease sale area. This chapter discusses these potential effects.

Potential effects of oil and gas lease sales can be both positive and negative. Most potentially negative effects on fish and wildlife species, habitats, and their uses, on subsistence uses, and on local communities and residents can be avoided, minimized, or mitigated. DO&G mitigation measures can be found in Chapter Nine.

This best interest finding does not speculate about possible future effects subject to future permitting that cannot reasonably be determined until the project or proposed use is more specifically defined (AS 38.05.035). The effects of future exploration, development, or production will be considered at each subsequent phase, when various government agencies and the public review permit applications and other authorizations for the specific activities proposed at specific locations in the lease sale area.

It is important to note that in addition to the mitigation measures in Chapter Nine, all post-lease activities are subject to local, state, and federal statutes, regulations, and ordinances, some of which are listed as other regulatory requirements (lessee advisories) in Chapter Nine (see also Chapter Seven and Appendix B). Additional project-specific and site-specific mitigation measures may be required by permitting agencies, including DO&G, in response to public comments received during review of the proposed activity or as deemed necessary. Mitigation measures of Chapter Nine may also be changed or removed, and additional measures may be added, through the Call for New Information and supplement process described in Section E(2) of Chapter Two.

Leasing activities alone are not expected to have any effects, other than to provide initial revenue to the state. Post-lease activities could affect the terrestrial and freshwater habitats and wildlife, birds and fish of the lease sale area and uses of these resources. These activities could include seismic surveys related to exploration and development; environmental and other studies; excavation of gravel material sites; construction and use of support facilities such as gravel pads, staging areas, roads, airstrips, pipelines, and housing; transportation of machinery and labor to the site; and construction of drill sites and ongoing production activities. Unintended occurrences such as oil spills could also have effects.

A. Effects on Terrestrial Habitats, Wildlife, and Birds

In Arctic environments, the largest effects of oil and gas activities are from physical disturbances (Huntington 2007). Activities such as seismic surveys, road and other construction activities, and ongoing vehicle and human movements may alter landscapes and habitat. These can disturb the environment and contribute to behavior changes in wildlife, birds and fish. Below is a discussion of potential effects from activities such as surface land disturbances, seismic surveys, road and pad construction, and similar activities on terrestrial habitats, wildlife, birds in and near the lease sale area.

1. Potential Cumulative Effects on Terrestrial Habitats

During oil and gas exploration, development and production, various activities could impact vegetation and habitats in the lease sale area.

a. <u>Effects of Disturbances</u>

During the initial exploration phases, disturbances caused by cross-country travel and construction are the most significant (Hanley et al. 1983). Other activities that may induce impacts are installation of pile foundations in permafrost areas, construction of gravel roads, ice roads, ice pads and ice bridges, and general terrain disturbance (Hanley et al. 1981). Potential impacts can occur at all phases, but most are likely to occur during development and production. Disturbances related to construction for oil field development and pipeline construction may be the most significant disturbances (Hanley et al. 1983). Potential ecological effects of roads include physical disturbance, habitat loss, reduction in population of species in close proximity to the road, dispersal of wildlife, and mortality of wildlife. Habitat fragmentation may be a result, which may impact biological diversity (Spellerberg and Morrison 1998). Mitigation of negative impacts can be accomplished with appropriate measures, such as road edge management, containment of water run-off, and planning of roads to minimize habitat fragmentation and loss (Spellerberg and Morrison 1998).

Land surface disturbances may change and destroy vegetation, and can alter soils characteristics. Types of land surface disturbances may include vegetation clearing, slash disposal, altered soil

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Alpine field ice road.

characteristics, hydraulic erosion, altered surface hydrology, above ground obstructions and filled areas (Hanley et al. 1983). Disruption of the tundra surface may result in thermokarst in Arctic environments (Truett 2000, citing to MacKay 1970). Construction activities relating to petroleum extraction can cause impacts from the following: off-road transportation; road, pad and airstrip construction techniques; pile foundations in permafrost; below-ground pipelines and impacts to permafrost; ice roads; and terrain disturbance (Hanley et al. 1981).

Human activities can damage or remove the vegetative cover, leading to soil erosion (Hanley et al. 1981). The effects can alter the terrestrial habitat, and cause siltation of nearby freshwater habitats. Disturbance to permafrost areas removes the natural insulation, inducing thermal and hydraulic erosion, particularly in poorly drained, fine grain sediments. Disturbance can cause melting, erosion, heaving, slumping and subsidence (Hanley et al. 1981). The active layer of soil can undergo changes that cause settling, and can cause draining of areas previously frozen. Growth of depressions can cause more thawing and further subsidence, and potential deepening of Arctic lakes. (Hinzman et al. 1997, citing to Lawson 1986 and Waelbroeck 1993). Searching for adequate construction materials can also cause removal of gravel and disturbance of habitats (Hanley et al. 1983).

b. Effects of Construction Activities

Effects of constructing production pads, roads, and pipelines include direct loss of habitat acreage due to gravel infilling, and loss of dry tundra habitat due to entrainment and diversion of water. Construction of roads and gravel pads can interrupt surface water sheet flow and stream flows (NRC 2003). Prior identification of sensitive areas can support the construction of infrastructure away from sensitive habitats. In a study of the impacts to habitats from the construction of the Trans-Alaska Pipeline System, it was found that the greatest percent loss of habitat was from gravel material sites used for construction materials, with the work pad areas and road causing the next greatest habitat loss percentages (Pamplin 1979). A secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth (McKendrick 2000, Truett and Johnson 2000).

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Trench remediation, NE Pad L3, North Slope.

Construction activity involving vehicular passage (see below, Effects of Seismic Surveys), such as a rolligon, may upset the thermal balance of the permafrost beneath the tundra, especially in non-winter months. Based upon research by Jorgenson et al. (2002), differing vegetation types respond differently to the surface use of rolligon vehicles. The amount of time that is predicted for full surface revegetation after rolligon use ranged from 3 to 10 years, with differences attributed to type of vegetation, soil moisture characteristics, and level of disturbance. Dwarf shrub tundra generally showed a higher level of disturbance from rolligons than the moist wet sedge tundra vegetation (Jorgenson et al. 2002).

The effects upon the ecosystems impacted by roads include potential chemical input from roads to water bodies and to the airshed, and bioaccumulation in soils. Roads can impact fluvial dynamics, sediment transport and floodplain ecology. When roads alter habitats, plant species can be changed or removed, and nonnative plants can be introduced. Additional wildlife habitat impacts from roads can change the density, composition of animal species and populations (NRC 2003). The effects of roads can also include physical disturbance, habitat loss or fragmentation, and threatening or extinction of populations and species near the road edge, mortality of wildlife on roads, the use of road edges as habitat and dispersal of wildlife along road networks (Spellerberg and Morrison 1998).

The use of all-terrain vehicles (ATVs) on moist and wet tundra can disturb ground relief, vegetation and habitats. The impacts to tundra are dependent upon the amount of ATV use, the water content, the resulting impacts to tussocks, shrubs and lichens, and the effects of thermokarsting (Racine and Johnson 1988). Thermokarsting is a result of heat absorption by the tundra soils (McKendrick 2000, citing to McKendrick 1987; and Walker et al. 1987). It causes irregular land formation due to the uneven melting of permafrost.

Road construction, vehicular passage, and oil spills can alter surface albedo (reflectivity of sunlight off the earth's surface) or water drainage patterns, resulting in thaw and subsidence or inundation. Such changes can affect regeneration and revegetation of certain plant species, and species composition may also change after disturbance from construction activities (Linkins et al. 1984).

c. Effects of Seismic Surveys

Winter seismic surveys can affect tundra vegetation, depending on snow depth, vehicle type, traffic pattern, and vegetation type. Soil-water content, and the freezing and thawing cycles impact soil strength. Water that freezes in the soils impedes the movement of soil particles. In contrast, low soil-water content does not increase soil strength upon (Lilly et al. 2008). A study by Lilly et al. showed that while freezing, the soil temperatures colder than -2°C did not cause an appreciable increase in frozen soil water, and found that the difference in frozen soil-water content between -2° C and -5°C in early spring was less than autumn freezing conditions (Lilly et al. 2008).

Effects from seismic surveys during any season could be substantial if operations are conducted improperly. Vehicles can leave visible tracks in the tundra, but they should disappear with the recovery of the vegetation within a few years, especially in moist or wet vegetation areas. Vehicles using tight turning radii have sheared off upper layers of vegetation, but left rhizomes intact, so those plants would probably recover. Dry, snowless ridges and vegetated sand dunes are at higher risk of damage. Damage was observed to shrubs, forbs and tussocks in research conducted by Guyer and Keating in 2001 and 2002. More significant impacts were observed on higher, drier sites, with little to no evidence of damage observed in wetlands (Guyer and Keating 2005).

The moving of equipment over land and the conducting of seismic surveys could alter the thermal balance, and increase the risk of thermokarsting. Studies of tundra disturbance from seismic surveys showed full or partial recovery over several years duration (Jorgenson and Cater 1996). Tundra plots were evaluated for vegetation, trail compression, visibility from the air, and exposed soil. Use of narrow trails and disturbance caused by camp moves showed partial recovery after ten years time, while other trails experienced almost full to full recovery. Impacts that persisted were trail subsidence, changes to wetter conditions, ruts, invasion of grasses, and decreases in shrubs. Use of 3D seismic methods may increase the surface footprint of the surveys, as a denser grid of trails is used than in the 2D surveys previously conducted (Jorgenson and Cater 1996).

d. Effects on Caribou Populations and Habitats

Direct habitat loss results from construction of well pads, pipelines, roads, airfields, processing facilities, housing, and other infrastructure. Effects of constructing pads, roads, and pipelines on caribou habitats include direct loss of acreage due to gravel infilling, and loss of dry tundra habitat due to entrainment and diversion of water. The long term avoidance of human activities in oil fields by caribou constitutes a form of habitat loss, as well (Ballard et al. 2000, citing to Cameron 1995).

In comparison, other research showed that caribou are attracted to oil field infrastructure for insect relief (Ballard et al. 2000, citing to Ballard et al. 2000; Murphy and Lawhead 2000). Joly et al. (2006) support that oil development on Alaska's North Slope has not adversely affected caribou. Effects to individual animals may or may not represent net impacts to the caribou herd population overall, and those impacts may be positive or negative.

i. Effects on Caribou Calving and Post-calving

Cronin et al. (1994) found that caribou cow and calf groups are most sensitive to human disturbance just before calving and post-calving, but Haskell et al. (2006) found that caribou with or without calves became habituated to development after the calving period. Cameron et al. (2005) reported that caribou shifted calving inland, away from Milne Point, as infrastructure density increased. Ground vehicle traffic, aircraft, and human presence near cows with newborn calves also affect individuals as they migrate. If caribou are displaced from calving in a certain area due to construction, they are likely to calve in an area where construction is not taking place. The use of specific calving sites within the broad calving area varies from year to year. If calving caribou are displaced from high nutrition forage near a drill site or facility, they are likely to seek any protective area regardless of the forage. The cumulative effect of displacement from higher value calving habitat could be lower calf survival or calves with smaller mass and size (Arthur and DelVecchio 2009). On the other hand, high populations would force the caribou into lower nutrition areas anyway.

As discussed in Section 1(b), secondary effect of construction activities includes dust deposition, which may reduce photosynthesis and plant growth. Plants eliminated by dust along roads include sphagnum, acidophilus mosses and willow. If dust accumulation persists, all vascular plants may be eliminated. Caribou may be impacted by dust accumulation due to reduction in foraging plants, such as willow (McKendrick 2000, citing to Walker and Everett 1987; Ballard et al. 2000, citing to White et al. 1975 and White and Trudell 1980). In comparison, it has also been suggested that this dust shadow along roads allows for early melting of snow, increasing the earlier availability of forage vegetation to caribou in these locations (Cronin et al. 1994, citing to Lawhead and Cameron 1988).

ii. Effects of Roads

The use of roads has varying impacts on caribou. Caribou habituate to oil field structures, and habituate more slowly to vehicular traffic (Cronin et al. 1994). The observed density of caribou adjacent to roads showed that there was a significant decline in caribou in the zone of up to 0.6 mi from the road (Cronin et al. 1994). Caribou density increased at distances further than 0.6 mi, with an observed tripling of density in areas 2.5 to 3.7 mi from the road (Cronin et al. 1994).

During road construction in the Milne Point oil field, the estimated number of caribou within 2 km of the road declined by more than two-thirds during 1982-1987 (Nellemann and Cameron 1996). In contrast, Valkenburge and Davis (1986) reported that the Fortymile caribou herd moved to a new calving area, and chose a new area for several years duration (Valkenburg and Davis 1986). Although human activity may affect choice of calving areas, there is considerable natural variation in where calving occurs without human intervention (Valkenburg and Davis 1986).

Although aerial surveys of radio-collared females conducted between 1978 and 1987 indicate that parturient females ready to birth calves can be displaced by road systems (Cameron et al. 1992), more recent analysis suggests that calving and adult caribou distribution is not strongly influenced by the presence of the Milne Point Road (Noel et al. 2004). In the 1992 study, after construction of the Milne Point road, caribou were significantly less numerous within 1 km of roads and significantly more numerous 5 to 6 km from roads. A Noel et al. (2004) study of recent post-road calf densities reported that densities within 1 km of the Milne Point Road were higher than intervals farther from the road. In addition, the densities of all caribou were not lower closer to the road than at greater distances, as reported by other researchers. Roads without adjacent pipelines with heavy levels of vehicle traffic appear to impede caribou movement (Cronin et al. 1994).

Extensive research on the response of caribou to development has shown that for many situations it is possible to design facilities so that caribou movements are not significantly impeded. For example, in the Kuparuk development area, elevating pipelines and separating pipelines from roads with traffic have allowed caribou to move with ease through the oil field.

iii. Effects of Pipelines

Cronin et al. (1994) have found that caribou readily cross under elevated pipelines under most conditions. Elevated pipelines with adjacent roads with less than 5 vehicles per hour showed similar movement by caribou as areas with no vehicle traffic. Elevated pipelines and adjacent roads with moderate to heavy levels of vehicle traffic have been shown to impede caribou movements. Buried pipelines allow free passage of caribou. Noel et al. (2004) found that pipelines do not delay caribou travel to the coast.

Above-ground pipelines can restrict caribou movement and deter them from seeking preferred habitat unless provisions are made to allow for their free passage. It was found that pipelines elevated at least 5 ft allow for effective crossing by caribou, except when they were in proximity to roads with moderate to heavy traffic (15 or more vehicles per hour) (Cronin et al. 1994). Facilities and pipelines built earlier in the development of the Arctic oil fields and the Trans-Alaska Pipeline System likely created impediments to caribou movements (Shideler 1986). Group size of caribou affects the success of crossing linear structures, with larger groups showing lower success in crossings than do smaller groups (Shideler 1986). Flow and gathering pipelines were elevated only 1 to 4 ft above the ground, effectively barring caribou from crossing. However, extensive research on the response of caribou to development has now shown that for many situations it is possible to design facilities so that caribou movements are not significantly impeded. For example, in the Kuparuk development area, where elevating pipelines to a minimum of 5 ft above ground, and separating pipelines from roads with traffic, have allowed caribou to move freely through the oil field.

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Caribou under pipeline.

iv. Caribou Behavior for Insect Relief

The movements and behavior of caribou are strongly influenced by mosquitoes and flies. Caribou are harassed by mosquitoes (*Aedes spp.)* from late June to late July, and by oestrid flies (*Hypoderma tarandi and Cephenomyia trompel*) from mid-July through August (Ballard et al. 2000, Truett and Johnson 2000, citing to Dau 1986; Pollard et al. 1996). To escape mosquitoes, caribou move from inland feeding areas to windswept, vegetation free coastal areas, where they rely on various coastal habitats for relief from insect pests (White et al. 1975; Dau and Cameron 1986).

A variety of natural land features are used by caribou for insect relief (Roby 1978; Dau and Cameron 1986; Pollard et al. 1996, Ballard et al. 2000, citing to Pollard et al. 1996). Flies are less tolerant of shade, so when oestrid flies dominate, caribou favor shade created by industrial buildings and pipelines (Ballard et al. 2000; Murphy and Lawhead 2000). Gravel pads are also favored habitat for relief from both mosquitoes and flies (Ballard et al. 2000; Murphy and Lawhead 2000). Researchers found that ambient air temperatures were lower, wind speeds higher, and poor insect cover habitat likely made mosquitoes less abundant on gravel pads than on the tundra (Pollard et al. 1996).

v. Effects of Seismic Activities and Wells

A study in Alberta, Canada found that seismic lines did not act as barriers to caribou, and that roads were semi-barriers to animal movements. Maximum animal avoidance distances from well sites were reported to be 1,000 m, and avoidance distances from seismic lines and roads were 250 m (Dyer 1999).

vi. Effects of Aircraft Traffic

Caribou can be briefly disturbed by low flying aircraft, which can result in disruption of habitat use, with highly variable animal reactions, ranging from none to violent escape. Reactions depend upon distance from human activity; speed of approaching disturbance source; altitude of aircraft; frequency of disturbance; sex, age, and physical condition of the animals; size of caribou group; and season, terrain, and weather. Caribou in some herds appear to be habituated to aircraft; other herds respond with panicked running. Flights greater than 2,000 ft above sea level (asl) during calving, and flights greater than 1,000 ft asl at other times appears to cause little or no caribou reaction (Shideler 1986). In contrast, Calef et al. (1976), stated that during the spring and fall migrations, caribou react to aircraft flying less than 200 ft in altitude, and that above this height, disturbances were observed in less than 20% of all groups observed. They also found that during calving, there were strong panic and escape animal behaviors during overflights of less than 500 ft height (Calef et al. 1976). Panic reactions can cause animals to collide and injure themselves, with young calves being particularly susceptible to injury (Calef et al. 1976).

vii. Summary of Effects on Caribou

The Central Arctic and other herds found in the lease sale area have grown considerably during the period of oil field development, but researchers disagree about the impact of industry activity on caribou populations. Still, research indicates that caribou can accommodate and habituate to most oil field activities, although questions remain regarding the impact of high intensity or frequent disturbances (Murphy and Lawhead 2000, citing to Curatolo and Murphy 1986, 1987). Based upon comparisons with other herds, there have been no apparent effects of oil field development on the growth of the Central Arctic herd. This does not suggest that there may not be effects in the future, or that other herds under different ecological conditions may not be affected (Cronin et al. 1994).

e. <u>Effects on Other Terrestrial Wildlife Habitats</u>

Other terrestrial mammals that may experience cumulative effects of oil and gas development are the brown bear, muskoxen, moose, and other furbearers. Primary sources of disturbance include seismic activity, vehicle traffic, and aircraft.

Human activity may initially cause bears to avoid an area and can displace bears in the area. Seismic activity that occurs in winter may disturb denning bears. Studies have found that radio-collared bears in their dens were affected by seismic activities within 1.2 mi of their dens, demonstrated by an increased heart rate and greater movement within the den. However, no negative effect, such as den abandonment, was documented (Reynolds et al. 1986).

A study of the effects of roads on brown bears in British Columbia and Montana found that bears used areas within 100 m of roads significantly less than areas farther from the roads, but this behavior change did not translate into a demonstrable effect on the population (McLellan and Shackleton 1988). However, of greater concern to wildlife managers in the lease sale area is the potential for increased bear-human interactions and potential subsequent high nonhunting mortality of bears resulting from those interactions (ADF&G 2007; Suring and Del Frate 2002).

The ADF&G manages the GMUs where brown bears are found in and near the lease sale area, and have implemented management actions to reduce impacts on bears. Actions include closure of developed areas to big game hunting, prohibition of firearms within oil fields, and implementing bear safety and proper hazing techniques to reduce bear/human encounters. The proper management of wastes and landfills also reduce availability of anthropogenic foods to the bear population (Shideler and Hechtel 2000). If food is present, human activity serves as an attractive nuisance, attracting foraging bears, especially to refuse disposal areas. This may pose a threat to human safety and the potential need to remove "problem" animals. In 2001, five brown bears were shot in the Prudhoe Bay fields (NRC 2003).

Muskoxen have a high fidelity to particular habitat areas because of factors favorable to herd productivity and survival, such as food availability, snow conditions, or absence of predators. Therefore, displacement from preferred habitat could have a negative effect on muskoxen

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Muskoxen in front of a production site, Prudhoe Bay.

populations. Muskoxen conserve energy and remain relatively sedentary in the winter and calving,to conserve energy to compensate for reduced forage (Reynolds et al. 2002). Mixed groups of muskoxen showed a greater sensitivity to fixed-wing aircraft in winter and during calving than in summer, fall, or during rut. Helicopters and low-flying aircraft have sometimes caused muskoxen to stampede and abandon their calves (NRC 2003). Muskoxen also may react to seismic survey equipment operating within 2 mi from the herd, and move away from the equipment and sounds emitted. Research has shown that the animals return from 1 to 4 weeks after the disturbance (Russell 1977). Muskoxen may react to visual stimulus rather than the noise of the disturbance source. On level land the disturbance was much less that in more rolling terrain, where more sudden appearance of a vehicle caused a disturbance. Aircraft and snow machines caused a disturbance at greater distances than Nodwell vehicles (Beak Consultants Ltd. 1976).

The presence of linear pipelines may affect moose habitats, causing disruption in migration movements. A study of the effect of the Trans-Alaska pipeline on moose habitats suggested that moose are physically prevented from crossing under pipe structures that are less than 4 ft above ground level (Van Ballenberghe 1978). During shallow snow conditions about 60% of all moose crossings occurred when distances were between 6 to 8 ft high. Three-quarters of all crossings occurred where the pipe was 8 ft or less above ground, and more than 90% used crossing locations that were less than 10 ft high. Open ditches of 10 ft or more in depth deflected moose migration (Van Ballenberghe 1978).

Wolves and foxes are found in the lease sale area. Foxes readily habituate to human activity, and this can lead to human-animal encounters, the foxes' use of human structures, and attraction to anthropogenic food sources. Foxes are especially attracted to human activity because of potential scavenging sources (Burgess 2000, citing to Wrigley and Hatch 1976; Eberhardt 1977). Animal disturbance can be caused by aircraft traffic. Human use of land with denning sites can force animals to move (Eberhardt 1977). Ice roads connecting well sites and supply areas provide a source of disturbance from vehicles, and access to animals that may be perceived as a nuisance (USFWS 1987). Foxes have been attracted to camps where workers provided food handouts (Eberhardt 1977). During construction of the Dalton Highway and TAPS, wolves readily accepted handouts from construction workers (McNay 2002). When wolves approached humans, they were sometimes shot (McNay 2002). Foxes and wolves are also noted for rabies outbreaks, which increase when population densities are high and which add risks to human health. Oil and gas activity may attract foraging foxes and wolves, especially to refuse disposal areas.

Wolverines are primarily scavengers and are cautious and wary of humans (Krott 1960). Wolverines apparently are not attracted to garbage (USFWS 1986). Van Zyll de Jong (1975) reported that evidence of declining wolverine populations in Canada were found in areas of relatively dense human populations. The human hunting and exploitation of wolverines were thought to be the direct or indirect causes of decline of the wolverine population in those areas (Van Zyll de Jong 1975). Habitat destruction can also affect wolverine populations (Magoun 1985).

f. Effects on Bird Populations and Habitats

The numerous migratory birds that are found in the North Slope Foothills use the area for important breeding, nesting, rearing, staging, refugia, and overwintering habitat. Some bird habitats located north of the foothills on the North Slope's Arctic coastal plain have been impacted by oil and gas infrastructure, such as pads, pipelines, roads, and gravel pits, and community development, such as residences, schools, airports, roads, and landfills (MMS 2008). Disturbance and habitat loss of birds may occur as facilities are developed, on tundra habitats used by birds for nesting, foraging, brood rearing, and molting. For example, regular vehicle traffic on roads could permanently displace nesting birds near the development. Secondary effects, including changes in drainage patterns, thermokarst, deposition of dust, and disturbance associated with activity on roads, can displace additional individuals. Collision of birds with manmade objects may occur.

Studies conducted about the human effects of the habitats of the Pacific loon in or near oil fields report that disturbances are caused by construction of gravel roads and pad and human activity. Disturbance of nest sites, reduced availability of food sources, and abundance of predators may affect the bird populations (Kertell 2000, citing to Kertell 1996, 1997). The common eider and

Lapland longspurs sometime select gravel fill for nesting sites (McKendrick 2000). Changing the water regime with impoundments and limiting movement among wetlands may compromise access to birds' food supply (Kertell 2000, citing to Walker et al. 1987).

The tundra swan habitats in or near oil fields have experienced some human impacts and habitat loss due to the construction of gravel roads, pads, material sites and other permanent infrastructure (Ritchie and King 2000). The selection of nesting habitat has been more important than oil field facility avoidance (Ritchie and King 2000). Road noise and human presence, including pedestrians, on roads have caused some swans to nest farther from the road than they had previously (>100 to 200 m) (Ritchie and King 2000, citing to Murphy and Anderson 1993).


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Swan in front of a production facility, Prudhoe Bay.

Disturbance is most likely to have an impact to bird habitat during those periods when birds have difficulty in meeting their daily energy requirements, especially when food intake needs to be high to enable birds to build up nutrient reserves in advance of periods of high demand (MMS 2008).

Effects of aircraft traffic on birds have been studied for several species, locations, and types of aircraft with varying results. Studies regarding the impact of low altitude overflights by helicopter or other aircraft traffic can adversely affect birds by causing stress and the flushing of habitats and nests (Rojek et al. 2007). Research relating to aircraft disturbances of common murres along the California coast showed that aircraft noise and the presence of aircraft flying below 1000 ft altitude caused head-bobbing behavior or flushing of part or all of a bird colony (Rojek et al. 2007). Helicopters can cause more disturbance due to their low altitude capabilities (Rojek et al. 2007). Flushing and displacing adults and/or broods from preferred habitats during prenesting, nesting, and brood rearing and migration can cause disruption of courtship, chick loss, egg breakage, and predation by predators (Rojek et al. 2007).

Research by Ward and Sharp (1974) evaluated the impacts of helicopters to moulting sea ducks on Herschel Island, Canada. They found that helicopter disturbances at 100 m height had an immediate impact, but that bird behavior showed no lasting effects. Helicopter disturbances did not drive birds from the habitat, and helicopter overflights at 300 m did not affect bird behavior (Ward and Sharp 1974).

In a 4-year study by Ward et al. (1999), they observed the effects of aircraft overflights on Pacific brant and Canada geese in Izembek Lagoon, located in Southcentral Alaska. The findings showed that 75% of the Pacific brant and 9% of the Canada geese flew in response to overflights. The Pacific brant were more reactive to helicopter rotary wing aircraft (51%) and louder aircraft (49%), as compared to fixed-wing (33%) and low-noise aircraft (40%) (Ward et al. 1999). The Canada geese were more reactive to helicopter rotary wing aircraft (41%) and louder aircraft (43%), as compared to fixed-wing (20%) and low-noise aircraft (31%) (Ward et al. 1999). The greatest response was to flights at intermediate altitudes of about 1000 to 2300 ft. Lateral distance from the birds was also a critical factor in determining the amount of disturbance to the birds (Ward et al. 1999).

Finally, Larned et al. (1997) found contrasting results about bird impacts from helicopters compared to fixed wing aircraft. They found that eiders tolerated close passes by helicopters at 150 m with mild alarm responses, while fixed wing aircraft caused the entire flock to leave with approaches within 150 to 200 m (Larned et al. 1997).

In research by Rojek, boat vessel approaches to common murre colonies along the coast also caused disturbances, with large disturbances causing some to birds to fly away leaving the habitat, and allowing other bird species to replace them (Rojek et al. 2007).

g. Effects on Terrestrial Habitats from Discharges from Gas Blowouts, Oil Spill Releases, and Drilling Waste Releases

i. Gas Blowouts

During drilling, shallow gas pockets of natural gas may be encountered. Gas can get trapped in soils, water, and ice in permafrost environments. Sediments in which gas has accumulated are potential hazards for drilling that penetrates them in Arctic environments (Natural Resources Canada 2010, citing to Hyndman and Dallimore 2001).

If a natural gas blowout occurs, the explosion and resultant fire would impact the immediate area, and gas vapors may migrate downwind. Natural gases, hydrogen sulfide, and gas condensates may impact any humans, plants, insects and other organisms in the immediate vicinity. If a natural gas blowout occurs, the initial explosion and possibility of fire are immediate hazards. Blowouts can also cause a toxic cloud of hydrogen sulfide to accumulate close to the ground (Van Dyke 1997). Natural gas and condensates that did not burn in the blowout would be hazardous to any organisms exposed to high concentrations.

ii. Oil Spills

The release of hydrocarbons can have toxic effects on vegetation, soils, wildlife, birds and fish. Effects of spilled oil on the tundra would depend on time of year, vegetation, and terrain. Oil spilled on the tundra would migrate both horizontally and vertically. The characteristics of the soil, such as porosity, permeability, texture, degree of water saturation and organic matter content, would affect oil movement (Jorgenson and Cater 1996). Oil flow would depend on many factors, including the volume spilled, type of cover (plant or snow), slope, presence of cracks or troughs, moisture content of soil, temperature, wind direction and velocity, thickness of the oil, discharge point, and ability of the ground to absorb the oil (Linkins et al. 1984). The principal means of oil transport are gravity, water flow, and diffusion in water or air (Jorgenson and Cater 1996). The spread of oil is less when it is thicker, cooler, or is exposed to chemical weathering. If the ground temperature is less than the pour point of the oil, it would pool and be easier to contain. If the oil is spilled on snow, it may be absorbed by the snow. Spilled oil that is warmer than snow may melt the snow and flow along the ground under the snow (Linkins et al. 1984, citing to MacKay 1975).

Absorption of the oil by the tundra itself would also limit flow and reduce the area contaminated. Experiments in Canada revealed that mosses have high absorption capacity (Linkins et al. 1984, citing to MacKay 1974). Moss-covered tundra can absorb more than 13 gal of oil per m^2, compared to less than a gallon for tundra not covered by moss (Linkins et al. 1984, citing to MacKay 1974). If there is a vertical crack through different soil horizons, oil would migrate down to the permafrost. If no cracks are present in the soil layers beneath the tundra, oil moves laterally in the organic material, does not penetrate the silty clay loam mineral soils beneath, and oil contamination would be restricted to the top few centimeters of the soil layer. Dry soils have greater porosity and the potential for vertical movement is greater (Linkins et al. 1984, citing to Everett 1978). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects, such as mortality or reduced regeneration, would occur in following seasons (Linkins et al. 1984). Hydrogen degrading bacteria and fungi can act as decomposers of organic material, and under the right conditions can assist in the breakdown of hydrocarbons in soils. Natural or induced bioremediation using microorganisms can also occur (Linkins et al. 1984; Jorgenson and Cater 1996). Tundra recovery from a crude oil spill in Prudhoe Bay showed complete vegetation recovery within 20 years without any cleanup (McKendrick 2000, citing to McKendrick et al. 1981). Natural recovery in wet habitats may occur in time durations of 10 years or less, if aided by cleanup activities and additions of fertilizer (McKendrick 2000).

Oil may cause harm to wildlife through physical contact, ingestion, inhalation and absorption. Oil toxicity can be related to the content of light aromatic hydrocarbons in the oil (Jorgenson and Cater 1996). As food sources are impacted by oil, larger animals, fish, mammals and humans can in turn be affected (USFWS 2004). Impacts to birds from oil releases may foul plumage and destroy insulation value, and resultant loss of buoyancy or hypothermia can kill birds (Burger and Fry 1993). While cleaning plumage, birds can ingest or inhale the oil, causing damage to lungs, liver, kidneys and death. Non-lethal effects to birds can include impaired reproduction or suppression of the immune system (USFWS 2004). Individual animals in the immediate vicinity and the associated nearby habitat and food sources may be impacted. Wildlife species may be disturbed or displaced. Additional efforts may need to divert wildlife from access to the impacted area.

Impacts to the terrestrial habitat could also result from disturbances associated with spill cleanup activities. These disturbances may cause positive effects by minimizing animals' and birds' direct contact with oil. The amount of damage to tundra by oil spills and the length of time that the oil persists decline with the site moistness, and increase with oil concentration at the site (McKendrick 2000, citing to Walker et al. 1978). Observations of a wet-sedge meadow affected by a crude oil spill showed that complete vegetation recovery occurred in 20 years without cleanup. In contrast, a dry habitat effected by a crude oil spill recovered to only 5% of the vegetation cover after 24 years (McKendrick 2000, citing to McKendrick 1999). Burning as part of oil spill cleanup immediately after the spill is a very effective cleanup method. Heat from a fire will not penetrate deeply into the soil, and tundra recovery will occur naturally (McKendrick 2000).

The action of removal of oil may be more damaging than allowing some residual oil to remain in place, in some cases. Oil weathers over time, and organisms may be able to tolerate the presence of oil while it is naturally degrading (Jorgenson and Cater 1996). The long term effects of oil may persist in the sediments for many years. Shifting of population structure, species abundance, diversity and distribution can be long term effects, especially in areas that are sheltered from weathering processes (USFWS 2004). Active clean-up measures must be planned to avoid additional adverse impacts, such as inducing thermal degradation, use of tundra damaging equipment and manpower activities, and further oil movement during thawing conditions. Passive measures may be the best means to facilitating natural recovery, as in the case of small or contained spills to minimize adverse effects to habitats (Linkins et al. 1984).

During the construction of the Trans-Alaska Pipeline from January through December, 1975, the most oil spills occurred due to equipment repair, refueling, or vehicular accidents (Kavanagh and Townsend 1977). It was determined that many small spills of less than 50 gallons could have been prevented by good maintenance procedures and consistent, careful handling techniques. The large spills of over 50 gallons were related to vehicular accidents or faulty fuel facilities in camps. Education of managers and employees that prevention due to good maintenance procedures and proper handling were recommended as the preferred policies and practices (Kavanagh and Townsend 1977).

iii. Releases of Drilling Muds and Produced Water

During exploration well drilling muds and cuttings are stored on-site, in holding tanks, or in a temporary reserve pit, and then hauled to an approved solid waste disposal site, or are reinjected into the subsurface at an approved injection well. Common drilling fluids contain water, clay, and chemical foam polymers. Drilling additives may include petroleum or other organic compounds to modify fluid characteristics during drilling (National Driller 2010). The down-hole injection of drilling muds and cuttings are unimportant if they are not placed into the subsurface into a drinking water aquifer (NRC 2003). This injection technique for mud and cutting disposal has greatly reduced the potential adverse impacts caused by releases of drilling muds and reserve pit materials (NRC 2003).

2. Mitigation Measures and Other Regulatory Protections

Mitigation measures minimize negative cumulative effects by planning and implementing exploration and development activities, along with associated infrastructure and roads, that minimize negative impacts. DO&G mitigation measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects. For example, DO&G mitigation measures require that impacts to important wetlands must be minimized. Exploration facilities, including exploration roads and pads, must be temporary and must be constructed of ice. Siting of material sites and roads must consider impacts to habitats to minimize adverse impacts to wildlife habitats. Exploration facilities, including exploration roads and pads, must be temporary and must be constructed of ice unless the director determines that no practicable alternative exists.

Technologies have been developed that may reduce the potential for impacting the tundra during seismic investigations (Jorgenson and Cater 1996). DMLW regulates use of tundra on the North Slope to prevent significant damage to the tundra. Each year, DMLW determines the date when North Slope tundra is open for use, and also determines the date for closure of tundra use. DMLW has determined that damage to vegetation can be avoided by limiting travel to areas with at least 6 inches of snow cover in wet sedge vegetation environments and 9 inches in tussock tundra, by monitoring soil temperature, and avoiding minimum radius turns (DMLW 2006). In areas where damage is extensive and natural recovery not expected, restoration may be required of operators. Use of non-native plants may be discouraged in certain habitats.

Conducting inventories to assist in site selection may prevent habitat degradation and reduction. Pollution prevention, habitat enhancement and management prior to, during and after construction are recommended (Spellerberg and Morrison 1998). In addition, DO&G mitigation measures in this best interest finding specifically address prevention of impacts to caribou and wildlife. Specifically, pipelines shall be designed and constructed to avoid significant alteration of movement and migration patterns of caribou and other large ungulates, and pipelines must generally be elevated at least 7 ft. The Alaska Caribou Steering Committee provides additional recommendations, such as that pipelines and roads should be separated by at least 500 ft (Cronin et al. 1994).

Disturbance caused by aircraft use is addressed by DO&G mitigation measures in this best interest finding. Aircraft travel shall remain one-half mile horizontal or 1,000 ft vertical from Dall sheep lambing areas between May 5 and June 20, and mineral licks from May 20 to June 30. Human safety will take precedence over flight restrictions. Lessee advisories in this best interest finding provide that seasonal restrictions may be imposed on activities located in, or requiring travel through or overflight of important calving or wintering areas for wildlife.

For projects near areas frequented by bears, mitigation measures in this written finding require that lessees prepare and implement a human-bear interaction plan designed to minimize conflicts between humans and bears, including reduction of attraction to garbage and food waste. Proper disposal of garbage and putrescible waste is addressed, and before commencement of any activities, lessees must consult with ADF&G to identify the locations of known brown bear den sites.

Oil and gas activities may have cumulative effects on bird habitats. Specific mitigation measures in this best interest finding require permanent, staffed facilities to be sited outside specified identified bird nesting and brood rearing areas. Lessees must also comply with USFWS and NMFS requirements regarding the Endangered Species Act, Migratory Bird Treaty Act and Appendix B of the "Yellow-billed Loon Conservation Agreement."

DO&G mitigation measures for this lease sale area are found in Chapter Nine.

B. Effects on Freshwater Habitats and Fish

1. Potential Cumulative Effects on Freshwater Habitats

Major anadromous rivers and streams within the lease sale area include the Colville, Sagavanirktok, Ivishak, Nanushuk, Echooka, Saviukviayak, Itkillik, Anaktuvuk, Kanayut, Lupine, Ribdon and Canning rivers, portions of the Chandler River, and Accomplishment, Upper Section and Lower Section, Flood, Cobblestone, and May creeks (Johnson and Klein 2009; Map 4.7 Anadromous rivers). These are the primary freshwater habitats in the lease sale area. Numerous other rivers and streams that flow through the sale area also support anadromous and sensitive overwintering fish populations. Several species of anadromous fish spawn and overwinter in these rivers and during summer migrate to nearshore coastal waters to feed. Migration patterns vary by species and within species by life stage (see Chapter Four). Potential effects include degradation of stream banks and erosion; reduction of or damage to overwintering areas; habitat loss due to gravel removal; high impact facility siting; effects due to water removal; siltation; impediments to fish passage and migration; and fish kills due to oil spills or freshwater habitat contamination. Excavation of gravel construction materials can cause disturb floodplains and habitats. Construction activities can also cause erosion of river banks, siltation, bottom substrate disturbance, reduced water volumes, altered water quality, barriers to fish passage, and elimination of habitat (Hanley et al. 1983).

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Alpine CD3 flowline over a side channel of the Colville River.

Erosion is a potential impact of all phases of exploration and development. Erosion results in siltation and sedimentation, which in turn may reduce or alter stream flow, affecting overwintering habitat availability and the ability of fish to migrate upstream. Protecting the integrity of stream bank vegetation and minimizing erosion are important elements in preserving fish habitat. Vegetated stream banks significantly reduce erosion of habitats (Muhlberg and Moore 1998). Streambeds could be affected if stream banks are altered, such as in cases of damage from equipment crossings.

A potentially limiting factor for fish populations in the Arctic is overwintering habitat. Removal of water from lakes, ponds and rivers where fish overwinter may affect the viability of overwintering fish, and longer-term effects of lake drawdown may impede the ability of fish to return to the lake in subsequent years. Removal of snow from lakes may increase the freeze depth of the ice, kill overwintering and resident fish, and adversely affect the ability of fish to utilize the lake in future years. Water depths of 7 ft or more are considered the minimum for supporting overwintering freshwater fish (ConocoPhillips Alaska Inc. 2010). Oxygen depletion, caused by overcrowding or over-demand by biological and chemical processes, can result in fish mortality (Schmidt et al. 1989; Reynolds 1997). The Ivishak River is known to provide consistently available overwintering habitat for anadromous fish in the lease sale area (Viavant 2007; Viavant 2008). Removal of snow from lakes may increase the freeze depth of the ice, kill overwintering and resident fish, and adversely affect the ability of fish to utilize the lake in future years.

The construction of roads across rivers and streams may also affect the ability of fish to reach habitat and overwintering areas by blocking movement and causing direct loss of overwintering habitat. Blockage of movement could also occur from the improper installation of culverts and fish crossings in streams for permanent roads. The blockage of passage, siltation of streams and destruction of spawning habitat were the main problems associated with construction of fish passage crossings along the Trans-Alaska Pipeline System (Gustafson 1977).

Unapproved gravel removal from fish bearing streams during development could adversely impact anadromous fish. Gravel removal could increase sediment loads, change the streambed course, cause instability upstream, destroy spawning habitat, and create obstacles to fish migration. Gravel removal from streambeds could also cause potential damage to overwintering fish populations. Any gravel structure that obstructs the natural migratory corridor near river or creek mouths has the potential to adversely affect anadromous fish. Alternatively, gravel mine sites can be restored as overwintering habitat and thus add to total available fish habitat.

a. Seismic Surveys

The principle impacts to freshwater habitats attributed to seismic surveys involve the acoustic energy pulses emitted by airguns. Seismic surveys typically cover a relatively small area and only stay in a particular area for hours, thereby posing transient disturbances. The airgun firing overpressures the water, and the fish react to the airgun, where fish immediately swim in an intense effort to flee from the sound.

In a study conducted in the Sagavanirktok River, when an airgun was fired in close proximity, after 2 minutes, the broad whitefish then slowed their swimming speed once again, and were observed to school as a group back at the original water location (Morris and Winters 2005). Repeated firing of the airgun revealed that this pattern was consistent, and fish returned to a sedentary posture at the original water location each time. The author’s interpretation of this study concluded that there was little evidence that energy from the airguns harmed the fish observed (Morris and Winters 2005). In a related study, the internal conditions of the fish were assessed after airgun firing to observe any organ damage that may have occurred from the disturbance. Airguns were fired in close proximity of Arctic char within a flooded gravel pit at Duck Island mine site on the North Slope. Results showed that no fish deaths occurred as a direct result of airgun noise, no bleeding of the gills was noted, but that internal injuries were observed in some fish. No swim bladder damage was observed.

Eye injuries were noted at rates ranging from 0.009 to 0.07, and body tissue injuries were noted at rates ranging from 0.06 to 0.12 in the fish. Fish eye injury was the injury with the highest frequency occurrence (Morris and Winters 2005).

Popper et al. (2005) measured the effects of seismic airgun firing on broad whitefish and found that the firing of airguns had no apparent effect on hearing. The results also showed that the lake chub species experienced only temporary hearing loss, and the northern pike hearing returned after 18 hours.

In a study of a rocky reef off Scotland, fish response from seismic airguns showed minor behavioral responses to airgun emissions. The researchers found there were no permanent changes in behavior, and no fish appeared to leave the reef habitat. There were no indications of observed damage to the reef animals (Popper and Hastings 2009, citing to Wardle et al. 2001).

Vessel traffic in rivers may disturb some fish resources and their habitat during operations. However, vessel noise is expected to be chiefly transient. Fish in the immediate vicinity of such vessels are believed likely to avoid such noise perhaps by as much as several hundred meters. Adverse effects from seismic activities to the migration, spawning, and hatchling survival of fish most likely would be temporary and localized (MMS 2007).

b. Effects on Freshwater Habitats from Discharges from Gas Blowouts, Oil Spill Releases, and Releases of Drilling Muds and Produced Water

i. Gas Blowouts

If a natural gas blowout occurs the initial explosion and possibility of fire are real hazards, and vapors may migrate downwind. Blowouts can also cause a toxic cloud of hydrogen sulfide that accumulates close to the ground (Van Dyke 1997). Natural gas and condensates that did not burn in the blowout would be hazardous to any organisms exposed to high concentrations.

ii. Oil Spills

Oil spills could range from small chronic leaks from equipment or facilities to catastrophic pipeline failures or, however unlikely, a blowout. The effects of oil spills on fish habitats would depend on many factors, including the time of year, size of the spill, and water body affected.

Fish can be impacted by oil uptake by the gills, ingestion of oil or oiled prey, and disruption of access to and changes to habitats (USFWS 2004). The impacts of the toxins in oil to freshwater invertebrates and fish are of concern (Jorgenson and Cater 1996). Potential adverse effects include direct uptake of oil by the gills, ingestion of oil, ingestion of oiled plankton or prey, effects on survival of eggs and larvae, and ecosystem changes in freshwater habitats. Adult fish may be affected by reduced growth, enlarged livers, heart and respiration rate changes and effects to reproduction. Due to toxic compounds in oil, spawning success may be reduced, and mortality of eggs and larvae could occur in spawning or nursery areas. Floating oil can also affect plankton, such as algae, fish eggs and invertebrate larvae (USFWS 2004). Sublethal effects may also reduce fitness and impair an individual’s ability to endure environmental stress. The long term effects to ecosystems impacted by oil spills due to persistence of toxic substances and chronic exposures may continue to affect wildlife (Peterson et al. 2003).

The freshwater habitats that were affected by the *Exxon Valdez* oil spill in 1989 were evaluated relating to the adverse effects of oil on embryos in the streams impacted by the spill. Bue et al. (1998) found that there was a significant embryo mortality rate from 1989 to 1993, but this elevated mortality rate was not repeated in 1994.

Research about the effects of oil to embryos in freshwater habitats demonstrated that water borne oil can kill pink salmon embryos downstream from oil sources. It was also found that the effects were varied, and that there was a potential for sublethal effects due to exposure to oil to impact fish later in their lifecycle (Heintz et al. 1999). The findings of a study to assess the delayed effects of crude oil in freshwater environments on pink salmon showed that there may be a relationship between impacts experienced by embryos exposed to crude oil and the long term survival rate of fish in the marine environment. Pink salmon exposed to crude oil as embryos had a 15% decrease in marine survival as compared to unexposed salmon (Heintz et al. 2000).

iii. Releases of Drilling Muds and Produced Water

Drilling muds, cuttings, produced waters, and other effluents from oil and gas exploration, development, and production can have short- and long-term negative effects on aquatic life, including fish and benthic organisms (Olsgard and Gray 1995). Lethal or sub-lethal effects may subtly reduce or impair physiological and reproductive fitness (Davis et al. 1984). Type and extent of effects depends on a myriad of factors including habitat involved, species, life history stage, migration patterns, nursery areas, season, type of chemical, amount and rate of release, time of release, duration of exposure, measures used for retaining of the chemical, and use of counteracting or dispersing agents (Davis et al. 1984).

Common drilling fluids contain water, clay, and chemical foam polymers. Drilling additives may include petroleum or other organic compounds to modify fluid characteristics during drilling (National Driller 2010). Releases to water environments that have concentrations above the concentration considered acceptable for aquatic life could cause toxic conditions (Woodward et al. 1988). Significant accumulation of drilling mud in wetlands can potentially impact benthic habitats and can blanket fish spawning grounds (Schmidt et al. 1999, citing to Falk and Lawrence 1973; and citing to Friedheim; Sprague and Logan 1979). Some research shows that bentonite mud may increase and improve the water holding capacity of soil (Schmidt et al. 1999, citing to Luginbuhl 1995). Suspended solids in aquatic habitat can have adverse effects on egg and larval development of amphibians (Schmidt et al. 1999, citing to Richter 1995). Produced waters may contain hydrocarbon and chemical constituents in volumes that may be toxic to microorganisms and mysid shrimp (*Mysidopsis bahia*) (Brown et al. 1992).

2. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities subsequent to leasing could potentially have cumulative effects on freshwater habitats, mitigation measures in this best interest finding, along with laws and regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate any potential effects.

Prevention of impacts from pads and roads includes containing waters and sediment load from flow into surface waters, using overpass and fish crossing structures, and compensating for loss of habitat (Spellerberg and Morrison 1998). The main fisheries problems associated with fish crossings are blockage of fish passage, siltation of streams and destruction of spawning habitat (Gustafson 1977). The primary failure mechanisms for fish crossings include poor materials, heavy traffic, thermal erosion, poor pad and low water crossings, scour and fluvial action. Pre-construction surveys should be done to find the natural low point of the stream crossing. Maintenance of the crossings is needed all year (Gustafson 1977). DO&G mitigation measures in this best interest finding address protection of fish and eggs from an oil spill, specifically, siting facilities away from fishbearing streams and lakes; development of oil spill contingency plans; and providing adequate spill response equipment staging and training.

Adverse impacts to overwintering habitat from oil releases can be damaging to fish. Because of the many variables involved, it is not clear prior to a spill what the impacts would be that would affect the long term survival rate of fish and the fish population. Exploration and development must take these overwintering habitat locations into consideration in planning, and should implement mitigation activities that prevent any adverse impacts to these freshwater habitats. The crossing of fish habitat waters, and the use of water for exploration and development are regulated by the ADF&G and ADNR. Please refer to Chapter Seven for details about the governmental powers related to management of freshwater habitats.

To protect fish eggs, DO&G considers mitigation measures on a case-by-case basis as a condition for obtaining a geophysical exploration permit. Mitigation measures for geophysical exploration permits may include limiting the timing of seismic work and requiring that seismic activities be set back from freshwater fish spawning areas so that shock waves are reduced to safe levels before reaching incubating eggs during sensitive stages of development.

DO&G mitigation measures for this lease sale area are found in Chapter Nine.

C. Effects on Water Resources

1. Potential Cumulative Effects on Water

Potential cumulative effects on water quality would probably be due primarily to three factors: discharges of drilling muds, cuttings, and produced waters; increased turbidity from construction of gravel structures, roads and pipelines; and oil spills. Water use from lakes, ponds or groundwater wells may be required for the construction and maintenance of ice roads and pads, for blending drilling muds in drilling activities, and for potable and domestic water uses at drilling camps (NRC 2003; Van Dyke 1997).

Turbidity, which is related to suspended particles in the water column, could increase if pipeline construction or repairs, or gravel structure construction were performed improperly or without following regulations and industry protocols. Water quality characteristics that could potentially be affected by oil and gas activities include: pH, total suspended solids, organic matter, calcium, magnesium, sodium, iron, nitrates, chlorine, and fluoride. Potential activities that might affect surface water quality parameters include accidental spills of fuel, lubricants, or chemicals; increases in erosion and sedimentation causing elevated turbidity and suspended solids concentrations; and oil spills.

Geophysical exploration with tracked seismic vehicles is not expected to alter water quality because seismic surveys are conducted in winter and permit conditions mitigate potential damage. Under standard ADNR permit conditions for winter seismic exploration, the use of ground-contact vehicles for off-road travel is limited to areas where adequate ground frost and snow cover prevent damage to the ground surface.

The extent and duration of water quality degradation resulting from accidental spills would depend on the type of product, the location, volume, season, and duration of the spill or leak, and the effectiveness of the cleanup response. Heavy equipment, such as trucks, tracked vehicles, aircraft, and tank trucks, commonly use diesel fuel, gasoline, jet fuel, motor oil, hydraulic fluid, antifreeze, and other lubricants. Spills or leaks could result from accidents, during refueling, or from corrosion of lines (ADEC 2007).

2. Potential Effects of Releases of Drilling Muds and Produced Water

Byproducts of drilling and production activities include muds and cuttings, produced water, and associated wastes. Improper disposal or accidental releases of drilling muds, cuttings, produced waters, and other effluents from oil and gas exploration, development, and production could have short- and long-term negative effects on fresh water habitats, as discussed in Section B above. Cumulative impacts from exploration and development activities may affect water quality.

Technological advances in drilling mud systems have developed mud systems less toxic to the environment. Newer synthetic-based muds are formulated from synthetic organics base fluids. They produce even less waste, improve drilling efficiency, are reusable, and have advantages in environmental protection over oil or water-based muds. Synthetic muds can be reconditioned instead of discharged as waste (Wojtanowicz 2008).

Produced water contains naturally occurring substances such as clay, sand, oil, water, metals, and gas. These substances are found in the subterranean strata. Produced waters are usually saline with some level of hydrocarbons and naturally occurring solids and bacteria. They may also contain chemicals added to inhibit corrosion, as well as emulsifiers, coagulants, flocculants, clarifiers and solvents. Produced waters from gas production also can include condensed water, dehydration chemicals, hydrogen sulfide removal agents and chemicals that inhibit formation of hydrates (Veil et al. 2004). Produced waters may contain hydrocarbon and chemical constituents in volumes that may be toxic to microorganisms and mysid shrimp (*Mysidopsis bahia*) (Brown et al. 1992).

Associated wastes are other production fluids such as tank bottom sludge, well work-overs, gas dehydration processes, tank wastewater, and other residues that are considered non-hazardous (low-toxicity) by the EPA.

Most drilling wastes from onshore operations are disposed of under ADEC's solid waste disposal program. ADEC administers the oil and gas reserve pit closure program (18 AAC 60.200), for sites that previously used an on-site holding pit for drilling waste fluids. Re-injection is the preferred method for disposal of drilling fluids. Disposal of drilling muds and cuttings requires permit approval. Most oil field wastes are considered non-hazardous and waste fluids are recycled, filtered, and treated before reinjection or disposal. Cuttings and waste fluids must be made non-hazardous before injection. Produced water is treated using heat, gravity settling, and gas flotation devices to remove hydrocarbons. After treatment, produced water is reinjected into either the oil-bearing formation to maintain pressure and enhance recovery or into an approved disposal well. Cuttings disposal is done through grinding and injecting on-site, or cuttings are transported to an approved disposal site. Cuttings disposal can cost more than the total cost to drill a well. Wastewater, including sanitary and domestic graywater, is also treated to meet effluent guidelines before discharge. All disposal wells inject fluids deep beneath any drinking water aquifers.

The AOGCC functions as the regulatory agency overseeing the underground operation of the Alaska oil industry on private and public lands and waters, and ensures proper and safe handling and disposal of drilling wastes. AOGCC administers the Underground Injection Control (UIC) Program for oil and gas Class II wells, acts to prevent waste of oil and gas resources and ensures maximum recovery, and protects subsurface property rights.

3. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities subsequent to leasing could potentially have cumulative effects on water resources, mitigation measures in this best interest finding, along with laws and regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate any potential effects.

Under the standard ADNR permit conditions for off-road activity, fuel and hazardous substances must have secondary containment apparatus. An appropriately sized secondary containment or surface liner must be placed under all container or vehicle fuel tank inlet and outlet points. Appropriate spill response equipment must be on hand during any transfer or handling of fuel or hazardous substances. Vehicle refueling is prohibited within annual floodplains (DCOM 2004). Impacts and cleanup of crude oil spills are discussed in Chapter Six.

Other standard ADNR land use permit conditions serve to protect water quality from facility construction and operation. Work areas must be kept clean. Trash, survey markers, and other debris that may accumulate in camps or along seismic lines and travel routes that are not recovered during the initial cleanup must be picked up and properly disposed. All solid wastes, including incinerator residue, must be backhauled to an approved solid waste disposal site. Vehicle maintenance, campsites, and the storage or stockpiling of material on the surface of lakes, ponds, or rivers is prohibited (DCOM 2004).

Effluents discharged by the oil and gas industry are regulated through EPA's NPDES program. The administration of the program for oil and gas discharges is transitioning to ADEC in 2011, under the Alaska Pollution Discharge Elimination System (see Chapter Seven). Therefore fish and other aquatic organisms are not expected to be impacted by drilling muds, cuttings, produced waters, and other effluents associated with oil and gas exploration, development, and production.

Permits may contain stipulations on water use and quantity drawn in order to meet standards related to protection of recreation activities, navigation, water rights, or any other substantial public interest. Water use permits may also be subject to conditions, including suspension and termination of exploration activities, in order to protect fish and wildlife habitat, public health or the water rights of other persons. Before a permit to appropriate water is issued, ADNR considers local demand and may require applicants to conduct aquifer yield studies. Generally, water table declines associated with the upper unconfined aquifer can be best mitigated by industrial users tapping confined (lower) layers or searching for alternate water sources.

DO&G mitigation measures included in this best interest finding that address water quality include: protection of wetlands, riparian, and freshwater habitats; prohibition of discharges into waters; turbidity reduction; water quality monitoring; stream buffers; and water conservation.

DO&G mitigation measures for this lease sale area are found in Chapter Nine.

D. Air Quality

1. Potential Cumulative Effects on Air Quality

a. Current Air Quality Conditions

Oil and gas exploration, development, and production activities may produce emissions that potentially affect air quality. Gases are emitted to the air from power generation, flaring, venting, well testing, leakage of volatile petroleum components, supply activities and shuttle transportation (Arctic Council 2009).

Greenhouse gas emissions (CO^2 and CH^4) are another potential source of air pollution. These emissions come primarily from the burning fossil fuels in generators, vehicles, heavy construction equipment, aircraft, and camp operations, as well as the flaring and venting of natural gas. Fugitive sources account for a significant percentage of CH^4 emissions from oil and gas operations.

Air quality throughout the lease sale area is good. Concentrations of regulated pollutants are below the maximum allowed under the National Ambient Air Quality Standards (NAAQS).

b. Possible Effects to Air Quality

On-road and off-road vehicles, heavy construction equipment, and earth-moving equipment could produce emissions from engine exhaust and dust. Sources of air emissions during drilling operations include rig engines, camp generator engines, steam generators, waste oil burners, hot-air heaters, incinerators, and well test flaring equipment. Emissions could be generated during installation of pipelines and utility lines, excavation and transportation of gravel, mobilization and demobilization of drill rigs, and during construction of gravel pads, roads, and support facilities. Emissions could also be produced by engines, turbines, and heaters used for oil/gas production, processing, and transport. In addition, aircraft, supply boats, personnel carriers, mobile support modules, as well as intermittent operations such as mud degassing and well testing, could produce emissions (MMS 2008).

Other sources of air pollution include evaporative losses of volatile organic compounds from oil/water separators, tanks, pump, compressor seals, and valves. Venting and flaring could be an intermittent source of volatile organic compounds and sulfur dioxide (MMS 2008). Gas blowouts, evaporation of spilled oil, and burning of spilled oil may also affect air quality. Gas or oil blowouts may ignite. A fire could deposit a light, short-term coating of particulates over a localized area. In-situ burning of spilled oil must be pre-approved by ADEC and EPA and/or the U.S. Coast Guard (ADEC et al. 2008). Controlled in-situ burning of spilled oil is only allowed if it is located a safe distance from populated areas. Approved burn plans require removal of particulates. Other effects of reduced air quality include possible damage to vegetation, acidification of nearby areas, and atmospheric visibility impacts (BLM 2005).

c. Known Effects to Air Quality

An ambient Air Quality Monitoring Station has operated at Nuiqsut since 1999, originally as a State of Alaska permit condition for the Alpine field. Data collected indicate that air quality information from 2002 through 2005 showed Nuiqsut and Kuparuk field in compliance with both NAAQS and Alaska Ambient Air Quality Standards for all pollutants and averaging periods (BLM 2008, citing to Phillips Alaska and SECOR International Inc.).

The volume of 2002 emissions from the large stationary sources within the oil and gas industry in Alaska was 15.26 million metric tons of gross carbon dioxide equivalent. This is estimated as 7% of the total Title V large source emissions reported, and about 29% of all reported emissions in Alaska (ADEC 2008). The Alaskan overall oil and natural gas industry historical trend projection for emissions was an estimated 3.0 million metric tons of greenhouse gases statewide in 2005, contributing about 6% of the state's total greenhouse gas emissions (Roe et al. 2007). This is a projected decrease from 1990 and 2000, and continued decreases are expected through 2020. There are significant uncertainties with these estimates. These estimates are for fugitive emissions, which are released during the production, processing, transmission, and distribution of oil and gas. Fugitive emissions include methane and carbon dioxide released from leakage and venting at oil and gas fields, processing facilities, and pipelines. Estimates of emissions resulting from fuel combustion are only available for residential, commercial, and all industries combined, and are not available for the oil and gas industry separately (Roe et al. 2007).

The presence of an Arctic haze at higher elevations and from locally produced emissions is common among Arctic climates. It is reportedly primarily formed from fugitive emissions from temperate zone sources that are transported long distances. There is no definitive research about the interaction between local emissions and pollutants from distant sources (NRC 2003).

2. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities subsequent to leasing could potentially affect air quality, federal and state air quality regulations, particularly the Clean Air Act (42 USC §§ 7401-7671), 18 AAC 50, AS 46.03, and AS 46.14, are expected to avoid, minimize, and mitigate those potential effects. Therefore, additional DO&G mitigation measures are not included in this best interest finding because air quality regulations are under the jurisdiction of ADEC.

Because industrial emissions such as those listed above can have negative environmental effects, the federal Clean Air Act of 1970 and subsequent amendments regulate air quality across the U.S., including in Alaska (EPA 2010). Although the EPA is the primary federal agency responsible for controlling air pollution, monitoring air quality, and inspecting facilities (EPA 2010), many of these authorities in Alaska have been delegated to ADEC under a federally-approved State Implementation Plan (ADEC 2010b). State and federal regulations require facilities that emit certain pollutants or hazardous substances to obtain a permit: new facilities are required to obtain a permit before construction (Title I, NSR permit); existing facilities must have an operating (Title V) permit (ADEC 2010a). Permits are legally binding and include enforceable conditions. The permit limits the type and amount of emissions and requires pollution control devices, prevention activities, monitoring, and record keeping.

ADEC also operates ambient air quality monitoring networks under the provisions of the Prevention of Significant Deterioration Program to assess compliance with the NAAQS for: carbon monoxide, particulates, nitrogen dioxide, sulfur oxide, and lead; assesses ambient air quality for ambient air toxics level; provides technical assistance in developing monitoring plans for air monitoring projects; and issues air advisories to inform the public of hazardous air conditions (ADEC 2010b).

Operators in Alaska are required to minimize the volume of gas released, burned, or permitted to escape into the air (20 AAC 25.235(c)). Operators must report monthly to AOGCC any flaring event lasting over an hour. AOGCC investigates these incidents to determine if there was unnecessary waste (AOGCC 2004).

Additional information about air quality regulations and permits is found in Chapter Seven.

E. Wildlife and Fish Uses

1. Subsistence Uses

a. Potential Cumulative Effects on Subsistence Uses

Subsistence uses of the North Slope Foothills area are dependent upon the area's terrestrial and freshwater habitats. For centuries survival in the Arctic has centered upon the pursuit of subsistence foods and materials as well as the knowledge needed to find, harvest, process, store, and distribute the harvest. The development of Inupiat culture depended upon handing down traditional knowledge and beliefs about subsistence resources. For the Inupiat, subsistence and culture continue to be inextricably intertwined.

Subsistence uses of the North Slope Foothills area depend on the area's wildlife, fish and their habitats. Traditional subsistence activities include: hunting and fishing for caribou, muskoxen, brown bear, moose and other furbearers; hunting for migratory waterfowl and collecting their eggs; fishing for Dolly Varden, Arctic char, whitefish, salmon, Arctic grayling, rainbow trout, and burbot; collecting berries, edible plants, and wood; and producing crafts, clothing, and tools made from these wild resources. Equally important, subsistence activities also include social activities of consuming, sharing, trading and giving, cooperating, teaching, and celebration among members of the community. Potential cumulative effects to wildlife, fish, birds and fish, and their respective terrestrial and freshwater habitats are discussed in the preceding sections. Other potential effects on subsistence uses are discussed below.

Potential post-lease activities that could have cumulative effects on subsistence uses of the lease sale area include seismic surveys, discharges from well drilling and production, construction of roads and support facilities, and ongoing disturbances from production activities such as pipeline activities, vehicle, boat, and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during development and production. Potential effects on subsistence uses may also include: increased or decreased access to hunting and fishing areas; concerns about safety of subsistence foods; and increased competition for nearby subsistence resources. For example, roads built by oil companies during exploration and development recently and over the last 50 years are important for access to subsistence resources for the Cook Inlet area (Braund 2007). Increased access to hunting, fishing, and trapping areas, due to construction of new roads, could make access to subsistence areas easier and faster, but could also increase competition between user groups for subsistence resources.

Although the oil and gas industry has the potential to provide jobs and income to subsistence users, work in the oil and gas industry may reduce the time available for subsistence activities (Stanek et al. 2007; EDAW/AECOM 2007). Some studies have found that "higher levels of household cash income were directly correlated with peoples' commitment to, and their returns from, natural resource harvesting" (EDAW/AECOM 2007, citing to Kruse 1986, and to National Research Council 1999). Other studies have shown that young men in Inupiaq communities balance wage employment with seasonal subsistence activities, even when there are large numbers of high paying job opportunities (EDAW/AECOM 2007, citing to Kleinfeld et al. 1983). The availability of time-saving technologies, such as ATVs, snow machines, and outboard motors, has counter-balanced decreased availability of time, and "cash derived from wage employment did not replace subsistence but underwrote it" (EDAW/AECOM 2007, citing to Lonner 1986).

A major oil spill could decrease resource availability and accessibility, and create or increase concerns about food safety which could result in significant effects on subsistence users that could linger for many years. Subsistence harvests of fish and wildlife by residents of fifteen predominately Alaska Native communities, as well as by residents in larger rural communities, declined by as much as 77% after the 1989 *Exxon Valdez* oil spill (Fall 1999). The primary reason for the decline was the perception or fear that oil contamination had rendered the food sources unsafe to eat.

Within two years of the spill, subsistence harvests and participation had returned to pre-spill levels, although communities closest to the spill lagged behind. However, concerns remained about food safety, availability of many species was reduced, efficiency was reduced, and opportunities to teach subsistence skills to young people were lost (Fall 1999). By 2003, harvest levels were higher than pre-spill levels, or were within the range of other rural communities. However, harvest composition remained different from the pre-spill composition, and concerns about the safety of some shellfish species remained (Fall 1999). Additional complex factors may confound effects of an oil spill, including demographic changes in communities, and increased competition for fish and wildlife resources by other user groups and predators (Fall 1999). Because many subsistence resources affected by the spill had not fully recovered, subsistence in areas affected by the *Exxon Valdez* oil spill was still not considered to have fully recovered in 2006 (EVOSTC 2006).

It should be noted that publically available, quantitative, controlled studies that document cumulative effects of an oil spill on land or in freshwater are lacking. There is limited information available on whether spatial redistribution of a species, such as caribou, affects harvest and the time required to for a successful hunt (NRC 2003).

b. <u>Mitigation Measures and Other Regulatory Protections</u>

Although oil and gas activities subsequent to leasing could potentially affect subsistence uses, primarily as secondary effects from effects on habitat, wildlife, or fish, DO&G measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects. In addition to the DO&G mitigation measures addressing wildlife, fish, and habitat discussed in Section A(2) and B(2), other DO&G mitigation measures in this best interest finding specifically address harvest interference avoidance, public access, road construction, and oil spill prevention. In addition, a plan of operations must include a training program to inform the persons working on the project of environmental, social, cultural, health, and safety concerns.

DO&G mitigation measures for this lease sale area are found in Chapter Nine.

F. Sport Fishing and Hunting

1. Potential Cumulative Effects on Sport Fishing and Hunting

In addition to subsistence hunting and fishing, other important uses of fish and wildlife populations in the lease sale area include sport hunting and fishing. Potential post-lease activities that could have cumulative effects on these uses of the lease sale area include seismic surveys, discharges from well drilling and production, construction of road and support facilities, and ongoing disturbances from production activities such as pipeline activities, vehicle, boat, and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during development and production.

Sport hunting and fishing in the North Slope Foothills area depend on the area's habitats for wildlife and fish. Therefore, potential cumulative effects from oil and gas exploration, development and production on the area's terrestrial and freshwater habitats could also affect these uses. Potential effects to the area's habitats are discussed in the preceding sections.

Oil and gas exploration, development, and production could result in increased access to hunting and fishing areas. For example, roads built by oil companies during exploration and development recently and over the last 50 years are important for access to subsistence resources for the Cook Inlet area (Braund 2007), which would likely be true for user groups in other areas in Alaska, as well. However, increased public access to hunting and fishing areas due to construction of new roads could also increase competition between user groups for wildlife and fish resources.

2. Mitigation Measures and Other Regulatory Protections

Oil and gas activities subsequent to leasing could potentially have cumulative effects on uses of wildlife and fish populations, such as sport hunting and fishing. Most of these potential effects would likely occur as secondary effects from effects on habitats, wildlife or fish. DO&G measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects. In addition to DO&G mitigation measures addressing habitats, wildlife, and fish, other DO&G mitigation measures specifically address harvest interference avoidance.

DO&G mitigation measures for this lease sale area are found in Chapter Nine.

G. Historic and Cultural Resources

1. Potential Cumulative Effects

The lease sale area has documented occurrence of historical and cultural resources found throughout the area (Dale 2009). The potential impacts to these resources may be from accidental oil spills, erosion and vandalism (Dekin et al. 1993). The expected effects on archaeological resources from an oil spill are uncertain. However, during the *Exxon Valdez* oil spill and subsequent cleanup activities, the greatest effects to cultural resources came from vandalism and direct disturbance during cleanup activities (Bittner 1996).

If development occurs, impacts and disturbance to historic and cultural resources could be associated with installation and operation of oil and gas facilities, including drill pads, roads, airstrips, pipelines, processing facilities, and any other ground disturbing activities. Damage to archaeological sites may include: direct breakage of cultural objects; damage to vegetation and the thermal regime, leading to erosion and deterioration of organic sites; shifting or mixing of components in sites resulting in loss of association between objects; and damage or destruction of archeological or historic sites by oil spill cleanup crews collecting artifacts (USFWS 1986).

In the event that an increased amount of ground disturbing activity is a planned for historically and culturally rich areas, state and federal laws and regulations can mitigate effects to archaeological resources. The Alaska Office of History and Archaeology requires that any cultural resources found be reported to their office. Please see Chapter Seven, for more information about the Alaska Office of History and Archaeology.

a. Gas Blowouts or Explosion

Disturbance to historical and archaeological sites might occur as a result of activity associated with incidents such as an oil or gas well blowout, or explosion. Archaeological resources in the immediate vicinity of the blowout might be destroyed, and cleanup activities could result in disturbance by workers near the accident site, as discussed above.

b. Oil Spills

Oil spills can have an indirect effect on archaeological sites by contaminating organic material, which would eliminate the possibility of using carbon C-14 dating methods (USFWS 1986). Subsequent to the *Exxon Valdez* oil spill, the detrimental effects of cleanup activity on these resources were minor because the work plan for cleanup was constantly reviewed, and cleanup techniques were changed as needed to protect archaeological and cultural resources (Bittner 1996).

2. Mitigation Measures and Other Regulatory Protections

Historic and cultural resources could be affected by oil and gas exploration, development, and production activities. For example, historic and cultural resources may be encountered during field based activities, and these resources could be affected by disturbance, or accidents, such as an oil spill. Various mitigation measures used to protect archaeological sites during oil spill cleanups include avoidance (preferred), site consultation and inspection, onsite monitoring, site mapping, artifact collection, and cultural resource awareness programs (Bittner 1996).

Although oil and gas activities subsequent to leasing could potentially have cumulative effects on historic and cultural resources, DO&G measures in this best interest finding, along with regulations imposed by other state, federal and local agencies, are expected to avoid, minimize, and mitigate those potential effects.

Because historic and cultural resources are irreplaceable, caution is necessary in order to not disturb or impact them. AS 41.35.200 addresses unlawful acts concerning cultural and historical resources. It prohibits the appropriation, excavation, removal, injury or destruction of any state owned cultural site. In addition, all field based response workers are required to adhere to historic properties protection policies that reinforce these statutory requirements, and to immediately report any historic property that they see or encounter (AHRS 2010).

Under MSB municipal code, proposed development may not impact any historic, prehistoric, or archaeological resource before the assessment of that resource by a professional archaeologist (NSBMC 19.50.030(F)). MSB municipal code 19.70.050(F) states, “Development shall not significantly interfere with traditional activities at cultural or historic sites identified in the Coastal Management Program” (NSB 2010b). These provisions give the NSB authority to protect cultural and historic resources and current subsistence uses of these sites.

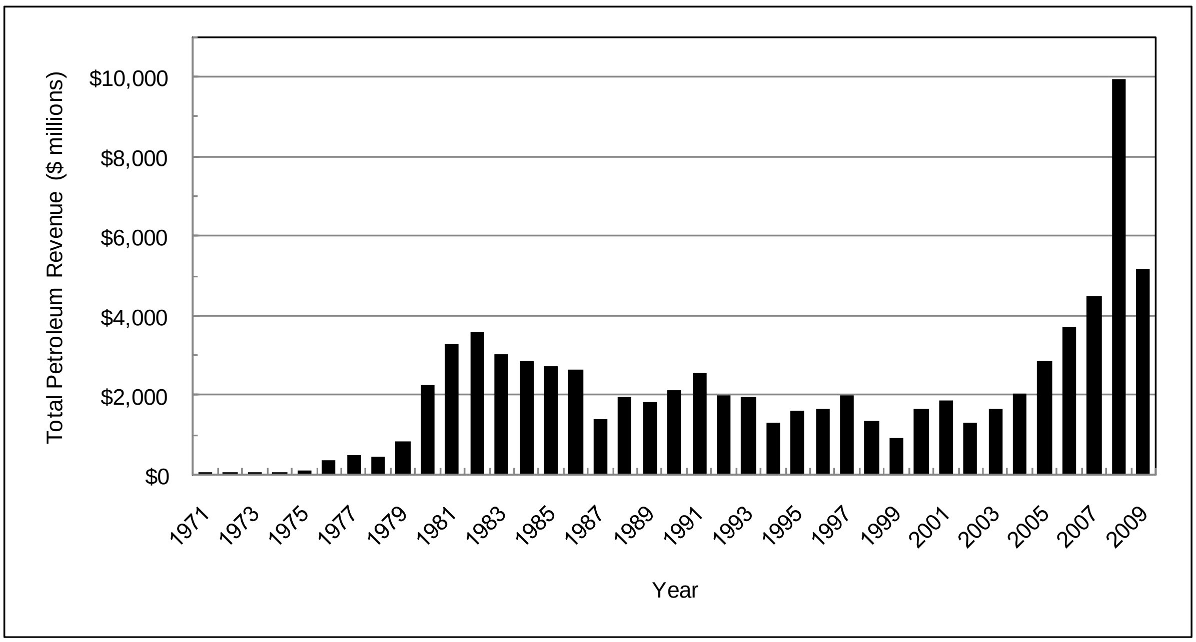
DO&G mitigation measures in this best interest finding address education and protection of historic and archeological sites. DO&G mitigation measures for this lease sale area are found in Chapter Nine.

H. Potential Cumulative Fiscal Effects on the State

Alaska's economy depends heavily on revenues related to oil and gas production and government spending resulting from those revenues. Oil and gas lease sales generate income to state government through royalties (including bonuses, rents, and interest), production taxes, petroleum corporate income taxes, and petroleum property taxes. Total oil revenue for FY 2009 was about $5.18 billion (Figure 8.1). Total projected oil revenue is $5.03 billion for fiscal FY 2010, and the projected oil revenue in FY 2011 is $4.66 billion (ADOR 2010). In addition, Alaska's oil resources are important to the nation, with about 17% of US oil production is from Alaska (Goldsmith 2008).

Bonus bid payments are the amounts paid by winning bidders for the individual tracts leased. Since 1959 through 2008, 6,954 tracts have been leased, generating more than $2.1 billion in bonus income and interest to the state (ADNR 2010a, ADNR 2010c)

Each lease requires an annual **rental payment**. The first year rent is $1 per acre or fraction of an acre, and the rent increases in 50-cent increments to $3 per acre or fraction of an acre in the fifth and all subsequent years of the lease. The lessee must pay the rent in advance and receives a credit on



Source: ADOR 1979; ADOR 2004; ADOR 2007b; ADOR 2009b.

Notes: Includes petroleum corporate income tax; production tax; petroleum property tax; oil and gas royalties (net); bonuses, rents and interest (net); and petroleum special settlements. Does not include Permanent Fund contributions and Constitutional Budget Reserve Fund.

Figure 8.1. Historical petroleum revenue to the State of Alaska, 1971-2009.

the royalty due under the lease for that year equal to the rental amount. Rental income from state leases for FY 2010 (July 2009 through June 2010) was approximately $8.7 million. In FY 2010, rental revenues received from federal leases were approximately $243,000 (ADNR 2010b).

Royalties represent the state's share of the production as the mineral owner. Royalties provided more than $1.4656 billion in revenue to the state in FY 2009 (ADOR 2010). The projected royalty revenue in FY 2010 is $1.5943 billion, and projected royalty revenue for FY 2011 is $1.562 billion (ADOR 2010). Royalty rates can vary depending on tracts. For the most recent North Slope

Foothills Areawide Oil and Gas Lease Sale held October 28, 2009, the royalty rate was 12.5% (ADNR 2010c).

Production taxes are the biggest source of state revenue. In 2007, the state replaced the Petroleum Profits Tax with the Alaska's Clear and Equitable Share. The revision increased overall rates and narrowed allowances for cost deductions and investment credits. For FY 2009 production tax revenue was $3.112 billion; for FY 2010 it is forecast to be $2.9433 billion, and $2.4922 billion for FY 2011 (ADOR 2010).

Corporate income taxes must be paid by all corporations in the state for all taxable income derived from sources within the state. Special provisions apply to apportioning total income worldwide for corporations involved in producing or transporting oil and gas. Most, if not all, producers and transporters of oil and gas in Alaska are corporations. For FY 2009, oil and gas corporation taxes were $492.2 million, and are forecast to be $390.0 million for FY 2010, and $500.0 million for FY 2011 (ADOR 2010).

Petroleum property taxes are annual taxes levied each year on the full and true value of property taxable under AS 43.56. This includes exploration property, production property, and pipeline transportation property. Property tax revenue amounted to $111.2 million in FY 2009, and is anticipated to be $106.4 million for FY 2010, and $104.1 for FY 2011 (ADOR 2010).

In addition, tax settlements to the Constitutional Budget Reserve Fund for FY 2009 amounted to approximately $202.6 million and NPR-A royalties, rents, and bonuses amounted to $14.8 million. Projected NPR-A revenues are projected to be $16.0 million for FY 2010, and $4.8 million for FY 2011 (ADOR 2010).

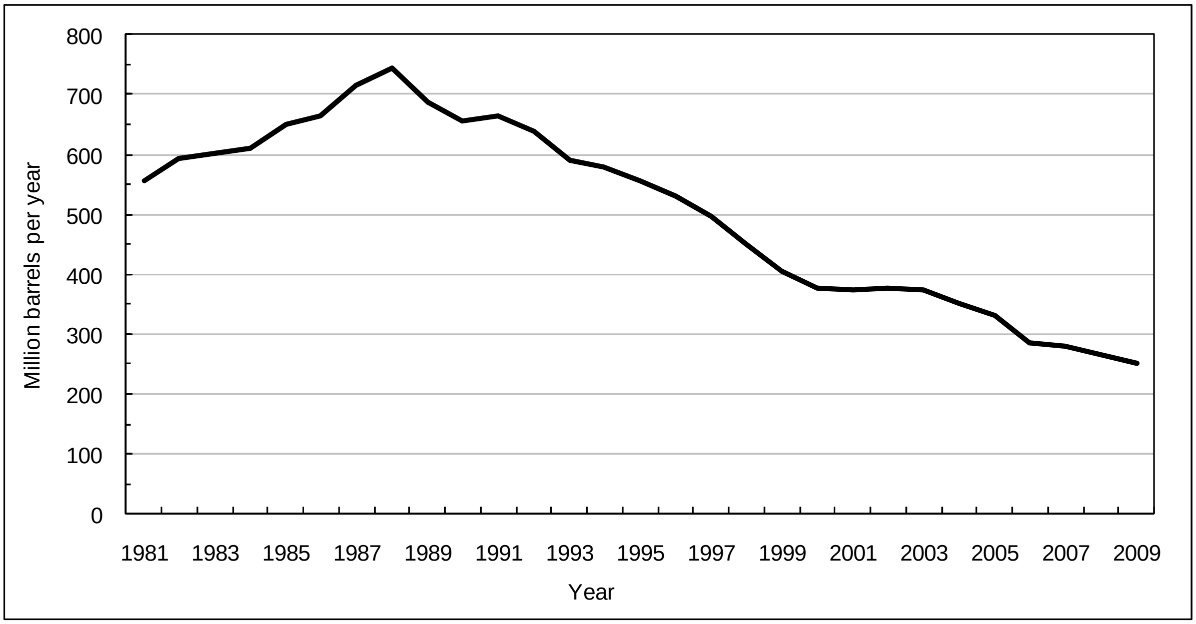
The oil conservation surcharge revenue to the state in FY 2009 was $11 million. This surcharge is applied to each taxable barrel of oil produced in the state (ADOR 2010). The purpose of the surcharge is to fund the oil and hazardous substance release prevention and response fund (AS 43.55.201; AS 43.55.300).

Unrestricted oil revenue comprised approximately 89% of the state's general fund unrestricted revenue in FY 2009 (ADOR 2010). Such revenues finance the state's education funding, operating budget, and capital budget.

Alaska North Slope production peaked at 2.006 million bbls per day in FY 1988 and has declined steadily since then (Figure 8.2). The oil production on the North Slope in FY 2009 was about 0.693 million bbls per day. The Alaska Department of Revenue (ADOR) anticipates production will decline by 6.6% in FY 2010 to about 0.650 million bbls per day, and projects 0.619 bbls per day for FY 2011. ADOR expects oil prices to average $76.13 per bbl in FY 2010, and $80.15 per bbl in FY 2011 (ADOR 2010).

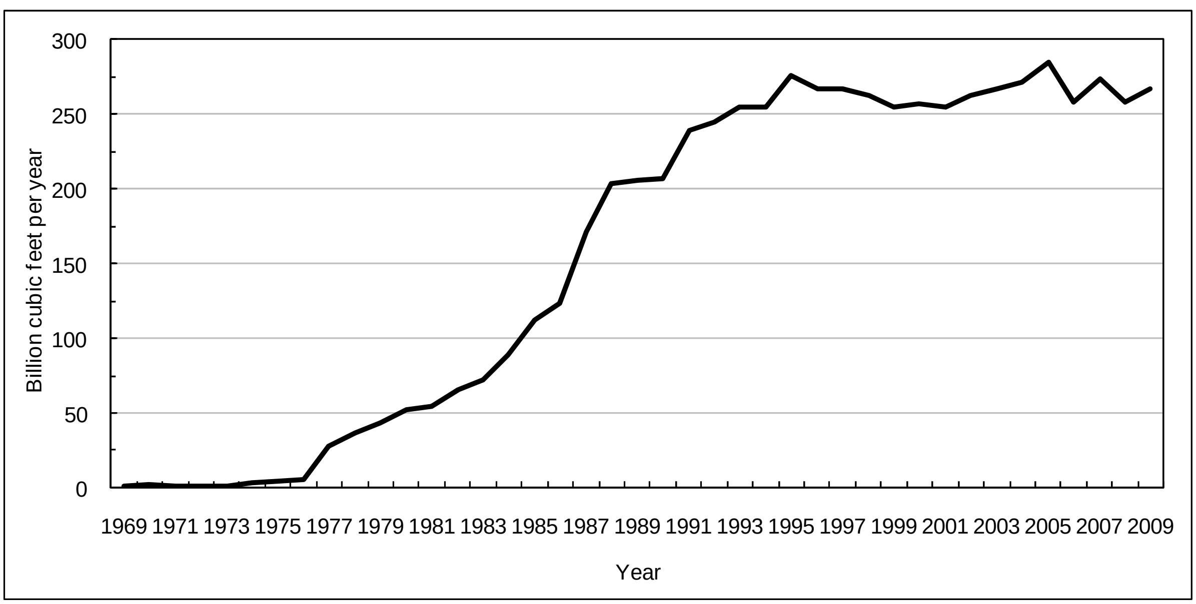
Production of natural gas on the North Slope has increased since 1969 (ADNR 2009). Production of gas increased significantly beginning in 1981, and production levels continue to increase (Figure 8.3). In some locations on the North Slope natural gas is injected back into the subsurface to maintain necessary pressures. Specific future production levels of gas are unknown at this time.

Oil and gas royalties and revenues also contribute to the Alaska Permanent Fund, which pays significant dividends each year to eligible state residents. The Alaska Permanent Fund, established by ballot proposition in 1976, is also funded with oil and gas revenues. Twenty-five percent of all revenue generated by oil and gas activities is placed in the fund, which reported a value of $35.2 billion in the end of the quarter on August 6, 2010 (APFC 2010). All eligible Alaskans who apply receive an annual PFD from the earnings of the fund. The PFD for 2010 was $1,281 per person; 641,595 dividends were paid, totaling $821.8 million (SOA 2010; Figure 8.4). The PFD is an equitable benefit transfer because it reaches every eligible Alaskan regardless of income or socioeconomic status. The PFD, with its large annual infusion of cash, contributes to the growth of the state economy, like any other basic industry.



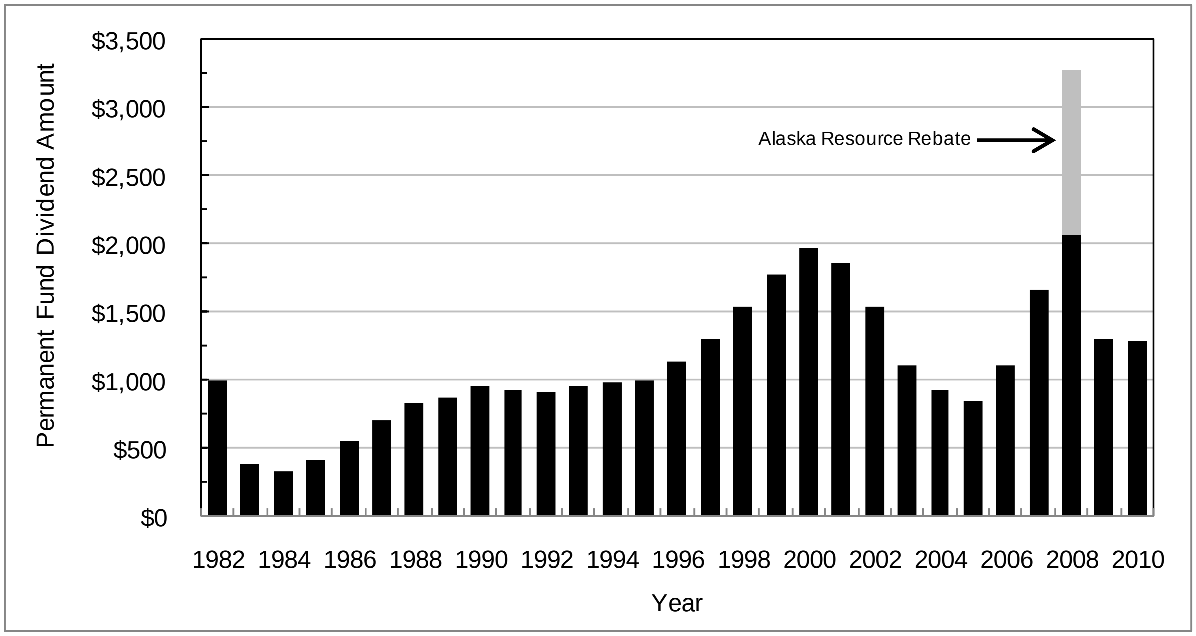
Source: ADNR 2009.

Figure 8.2. Alaska North Slope oil production, 1981-2009.



Source: ADNR 2009.

Figure 8.3. Alaska North Slope natural gas production, 1969-2009.



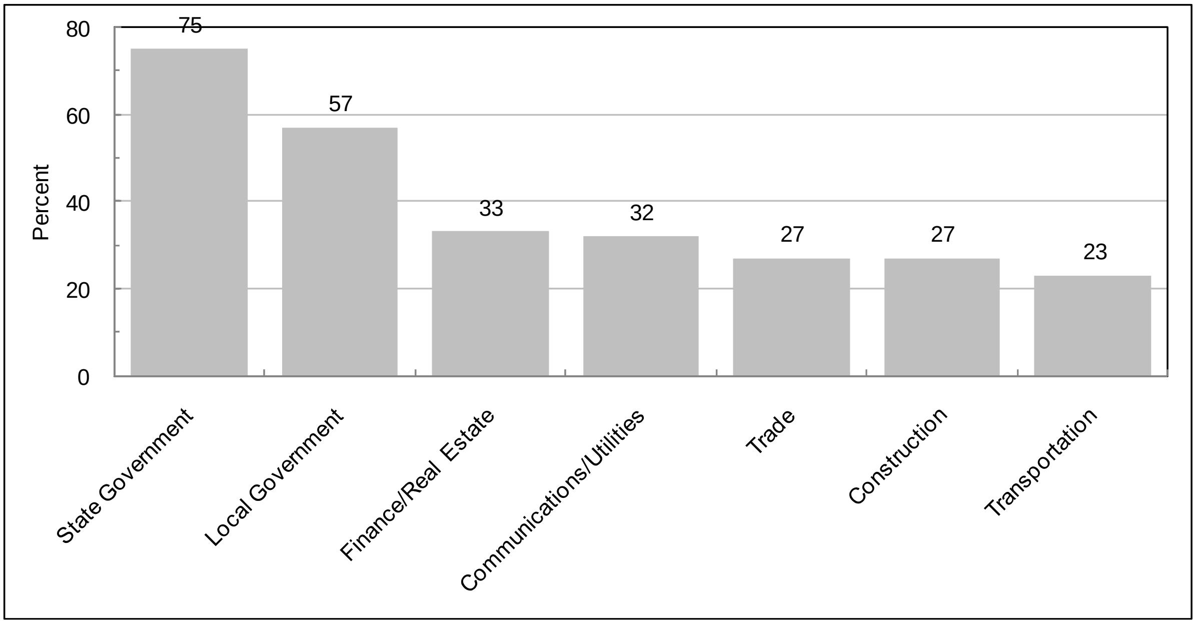
Sources: ADOR 2007a; ADOR 2008; ADOR 2009a; SOA 2010

Figure 8.4. Alaska Permanent Fund Dividend amounts, 1982-2010; includes Alaska Resource Rebate in 2008.

Jobs in the oil and natural gas industry comprise about 9.8% of Alaska's total workforce, with 3.8% direct employment, and 6% indirect and induced impacts on other industries (PriceWaterhouseCoopers 2009). This represents about 13.5% of the state's labor income in dollars, with 8.4% from direct employment, and 5.1% from indirect and induced impacts on other industries (NES 2009). The petroleum sector supports 75% of state government jobs, and more than half of local government jobs (Goldsmith 2008; Figure 8.5). The petroleum sector supports more than 100,000 jobs in Alaska, with about 5,000 jobs directly supporting oil and gas. More than a quarter in finance, utilities, retail and wholesale trade, and construction can be traced to the petroleum sector. The petroleum industry creates jobs in oilfield support, construction and other industries (Goldsmith 2008). State funding for the NSB School District (derived primarily from oil and gas revenues) was $11.66 million in FY 2009 for a student enrollment of 1,544 students (Table 8.1).

When state and local governments spend oil and gas revenues, Alaska's petroleum industry exercises significant indirect impacts on local communities. Money is spent throughout the state on capital projects, to support basic government operations (including payroll for state government employees), for revenue sharing and municipal assistance, to fund education, and to pay the annual PFD (Information Insights and McDowell Group 2001).

Furthermore, the total economic effects of any spending, including state government spending and salaries paid to private oil and gas industry employees, are always greater than the direct effect. When money is re-spent in the economy, its original value multiplies. For example, this "income multiplier" is calculated at 1.35 for state spending. This means that for every dollar of income Alaskans receive directly from state spending, an additional 35 cents of income is generated when that dollar is re-spent in the local economy (Goldsmith 1991).



Source: Goldsmith 2008.

Figure 8.5. Percent of Alaskan jobs that depend on petroleum.

Alaska's oil and gas industry is important to employment outside Alaska, as well. In 2006, nonresidents accounted for 30.8% of the statewide oil industry's workforce (major oil companies and oilfield services), an increase of 1.2 percentage points over 2005 (ADOL 2010a). Earnings paid to nonresidents working in the oil industry increased from $364.7 million in 2007 to $421.6 million in 2008. The nonresident share of earnings in the oil industry was 28% in 2008, a figure much higher than the statewide private sector average of 12.8%. By comparison, Alaska's seafood processing industry employed the highest percentage of nonresident workers of any industry sector in 2008; 74.4% of workers were nonresidents (ADOL 2010a).

The mitigation measures encourage lessees to employ local Alaska residents and contractors, to the extent they are available and qualified. Lessees must submit, as part of the plan of operations, a proposal detailing the means by which the lessee will comply with the mitigation measures. The plan must include a proposal with a description of the operator's plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors, per the lease Section 31.communities to recruit, hire, and train local and Alaska residents and contractors, per the lease Section 31.

Table 8.1. State aid and enrollment for the North Slope Borough School District, fiscal year 2000-2009.

	Fiscal Year									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Aid in millions	$8.96	$9.75	$8.94	$8.47	$8.70	$9.28	$11.60	$12.24	$10.22	$11.66
Enrollment	1,936	2,187	2,165	2,115	2,065	1,938	1,941	1,859	1,864	1544

Source: ADEED 2010a; ADEED 2010b.

I. Effects on Municipalities and Communities

1. Fiscal Effects on Municipalities and Communities

The North Slope Borough (NSB) is host to the production center for the state's oil industry and is influenced by the oil and gas industry. Although the borough relies on oil revenues as its primary source of income, most local residents pursue a traditional and community-based economic lifestyle (NRC 2003). The finances of the NSB government depend predominately on tax revenues from oil properties. Approximately 98% of all local property tax collections come from oil producers (ADOL 2010b). The revenue from these property taxes is about 88% of all NSB revenue (NSB 2010a).

Oil and gas property is exempt from local municipal taxation, but the state levies a 20-mill tax against this property. Each municipality with oil and gas property within its boundaries is reimbursed an amount equal to the taxes which would have been levied on the oil and gas property, up to the 20-mill limit. The 2009 property tax rate for the NSB was 18.5-mill (ADOL 2010b).

A critical issue facing the NSB is the potential for shortfall in revenues consequent to reductions in the assessed value of oil facilities as they depreciate. The oil and gas property tax revenue for the NSB in 2009 was $235 million, of the total property tax revenue of $239 million. For fiscal year 2010-2011, property tax receipts are anticipated to be $278 million (NSB 2010a).

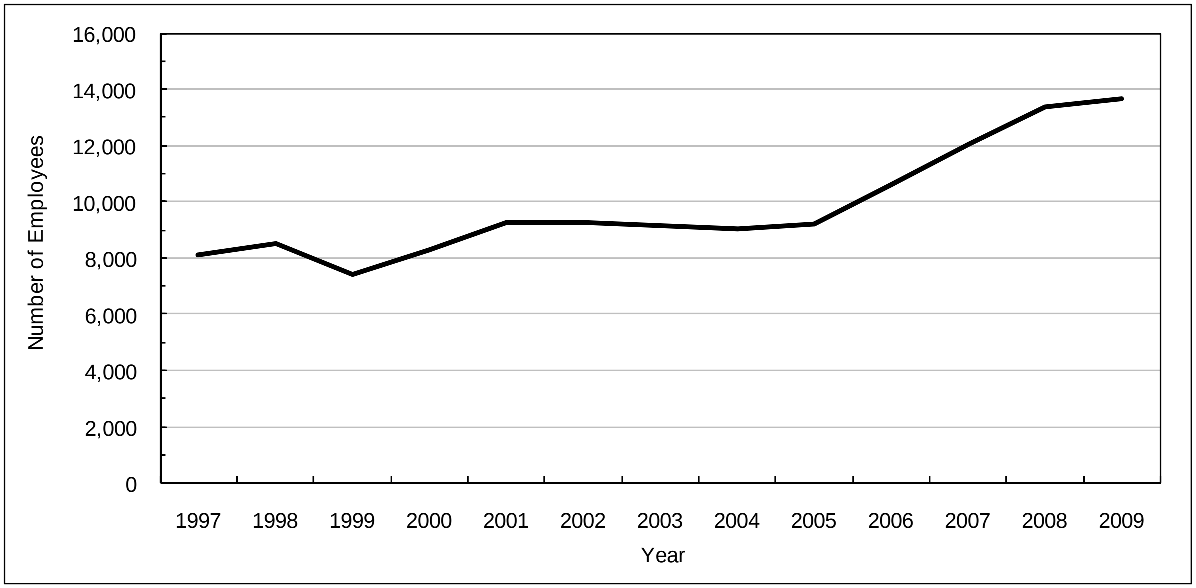
One of the NSB's main goals is to create employment for Native residents and it has successfully hired many Natives for NSB construction projects and operations. The NSB has been less successful facilitating employment of Native people in the oil industry at Prudhoe Bay. Reasons cited were that residents were not motivated to move for employment from their current residence location, that training of related skills to work in oil and gas development was needed, and that recruiting employees was done using methods common to western industry (MMS 2008, citing to Nageak 1998).

The NSB employs many permanent residents directly and finances construction projects under its Capital Improvement Program. The NSB pay scales have been equal to, or better than, those in the oil and gas industry, while working conditions and the flexibility offered by the NSB are considered by Alaska Native employees to be superior to those in the oil and gas industry. In addition, NSB employment policies permit employees to take time off, particularly for subsistence hunting (BLM 2007).

2. Fiscal Effects of the Oil and Gas Industry on Expenditures and Employment

The accumulated beneficial effects of oil and gas industry activity can be measured by net assets (public and private) per capita (NRC 2003). Regions that have a substantial tax base, such as the NSB, collect property taxes that provide many social services and reduce tax liability for private citizens. The NSB has used income generated from taxes, most of which comes from oil and gas sources, to create net public assets that were worth $1.8 billion in 2000. The combined income with all public and private assets totaled $13.4 billion, which was more than $1.77 million per capita. For small towns of Washington state with populations about the size of the NSB, the private per capita taxable net asset values for individuals, corporations, and other taxable sources average about $74,000 per capita; this compares to $1.53 million private per capita average for the NSB (NRC 2003).

Local government is the largest employer of NSB residents and the median household income in the Borough is $63,173 (ADCRA 2009b). In 2000, Borough, state, and federal agencies provided 61%



Source: ADOLWD 2009.

Figure 8.6. Average monthly employment for all industries in the North Slope Borough, 1997-2009.

of the total employment for the NSB. In 2009, four residents held commercial fishing permits. Figure 8.6 represents the average monthly number of employees for all industries in the NSB from 1997-2009. The estimated number of resident jobs by sector in the North Slope Borough communities in 2003 is shown in Table 8.2.

Table 8.2. Estimated number of resident jobs by sector for North Slope Borough communities, 2003.

Sector	Anaktuvuk Pass	Atqasuk	Barrow	Kaktovik	Nuiqsut	Point Hope	Point Lay	Wainwright
Federal Government	1	0	45	1	0	10	2	2
State Government	2	0	22	0	1	0	1	0
City Government	12	1	21	3	5	14	2	8
NSB Government	51	20	464	27	29	44	24	48
NSB School District	30	20	194	21	27	62	29	44
NSB CIP	0	0	4	0	2	0	1	3
Oil industry	3	0	14	1	3	2	0	0
Private Construction	4	0	23	5	3	1	4	4
ASRC	3	0	69	5	3	1	4	3
Village Corporation	19	27	87	18	37	60	9	38
Finance	0	0	5	0	0	0	1	0
Transportation	0	0	48	0	1	3	1	1
Communications	0	0	8	0	0	0	0	0
Trade	0	1	27	0	0	2	0	1
Service	4	0	103	0	0	0	1	0
Ilisagvik College	0	0	58	0	0	2	1	1
Other	2	3	132	3	10	25	5	18

Source: BLM 2008.

Barrow is a hub and economic center of the NSB. The US Census 2000 reported Barrow's per capita income at $22,902 and median household income at $67,097 (ADCRA 2009a). The number of people employed in Barrow increased from 2,194 in 1998 to 2,377 in 2003.

Employment opportunities are limited in Anakatuvuk Pass. The primary employers are the NSB and the school district, followed by city government and the Nunamiut Inupiat Corporation (URS Corp. 2005a, citing to Shepro and Maas 2003).

In Nuiqsut, education and other government services provide the majority of full-time employment. The Kuukpik Native Corporation and the North Slope Borough, including its school district, are the largest employers. In 2003, per capita income was $13,633 and household income was $59,907 (URS Corp. 2005c, citing to Shepro and Maas 2003).

The primary employers in Kaktovik are the NSB, NSB School District, and the Kaktovik Inupiat Corporation (URS Corp. 2005b). Craft sales are also part of Kaktovik's economy.

Very few Alaska Native residents of the North Slope have been employed in oil production facilities and associated work in and near Prudhoe Bay since production started in the late 1970s. In response to concerns about accommodating cultural and subsistence needs, BP Exploration initiated the Itqanaiyagvik Program, a training partnership with Arctic Slope Regional Corporation (ASRC), Ilisagvik College, and the NSB School District to provide education and training for oil industry professional and craft jobs (BLM 2008). ConocoPhillips has also worked closely with Kuukpik Corporation, ASRC, and other companies to hire and train Alaska Natives. ConocoPhillips, in cooperation with Kuukpik Corporation, sponsors mentoring and training at the Alpine field for North Slope residents. As a result of current development of the Alpine field, Nuiqsut has received a number of economic benefits and employment opportunities, including construction, catering, seismic, surveying, trucking, and security (BLM 2008). Nanook Incorporated, a subsidiary of Kuukpik Corporation, based in Nuiqsut, has a training program that could be used in the future to train Alaska Natives for positions in the North Slope Foothills in the oil industry, such as technicians and other long-term jobs (MMS 2008).

If exploration and development activities occur in the lease sale area, jobs could be added to the local economy. These jobs would not be limited to the petroleum industry, but would be spread throughout the government, trade, service, and construction industries. The number of jobs produced would depend on whether commercial quantities of oil and gas are discovered and developed. Discovery and development of commercial quantities of petroleum or natural gas in the lease sale area would probably bring direct economic benefits to the local and regional economy.

The standard of living of North Slope communities depends largely on a steady flow of money related to oil and gas activities. The current economies of these communities will be difficult to maintain unless significant revenues continue to come into these communities from oil and gas revenues; the prospects of other sources of revenue appear to be modest. Adjustments can and probably will be postponed for as long as oil and gas are being extracted, but eventual adjustment may be unavoidable. The nature and extent of these adjustments will be determined by the adaptations North Slope residents have made to the cash economy made possible by oil and gas and other activities (NRC 2003).

3. Public Health for Municipalities and Communities

Health status on the North Slope is determined by a wide array of factors, including genetic susceptibility, behavioral change, environmental factors, diet, and socio-cultural impacts. The scope of review for this best interest finding is to present current health related information, and is intended to consider and discuss the effects of exploration, development, production, and transportation involving oil and gas or gas only, as can be determined from the literature (AS 38.05.035(g)(B)(x)).

The causes of illness and resultant mortality rates of North Slope residents and workers have not been definitively correlated to specific natural or anthropogenic causes. However, changes in general health indicators on the North Slope have been documented. There have been investigations relating to disease and mortality rates for cancer, occurrence of social and psychological problems, suicide, diabetes, obesity and related metabolic disorders, cardiovascular and pulmonary diseases, and their rates of occurrence (BLM 2007).

As an example, several studies have presented information about the cancer mortality rates for Alaska Natives in the North Slope region, where the mortality rate from cancer was measured at 303/1,000, as compared with 163/100,000 in the US population (BLM 2007). The MMS (2008) reports that lung cancer is the most common variety of cancer in Alaskan Natives, and may be related to tobacco smoke. Chronic pulmonary disease mortality rates in the North Slope are the highest in the state, and are estimated at about three times that of the US population, 130/100,000 compared to 45/100,000, respectively (BLM 2007, citing to Day et al 2006). These health risk factors may be associated with rates of smoking documented on the North Slope.

Social and psychological problems on the North Slope have increased, including rates of alcohol and drug abuse, injury, assault, domestic violence and depression (BLM 2007). Overall suicide rates have increased since 1960 (BLM 2007, citing to Kraus and Buffler 1976 and Hicks and Bjerregaard 2006). The suicide rate on the North Slope has been estimated at about 45/100,000, about four times the rate estimated in the US population (BLM 2007, citing to Alaska Department of Vital Statistics 2006). In the young Inupiat male population, the suicide rate has been reported to be as high as 185/100,000, about 16 times the US population rate of suicide (BLM 2007, citing to Wexler 2006). To date, MMS (2008) reports that no research has been conducted to directly examine the impact of oil and gas operations on social and psychological health in the North Slope. Research suggests that in global Inuit societies, rapid socio-cultural changes have impacted the social and health related problems now being observed (BLM 2007, citing to Bjerregaad and Young 2004 and to Curtis and Kvernmo 2005, and to Goldsmith 2004).

There are observed reduced rates of diabetes and cardiovascular disease in the North Slope population, as compared to the US population, but rates are showing trends of increase. Public health researchers have noted that the lower mortality rates for these disease types may be attributed to subsistence diets (BLM 2007, citing to ANMC Diabetes Program 2006, and to Day et al 2006).

The state is currently developing a policy regarding Health Impact Assessments (HIA) for large resource extraction projects. HIA is a tool that seeks to identify potential lasting or significant changes, both positive and negative, of different actions on the health and social well-being of a defined population as a result of a program, project, or policy.

The Alaska Inter-Tribal Council received a grant from the Robert Wood Johnson Foundation to integrate an HIA into the federal environmental impact study process. In 2007, the NSB was awarded a $1.67 million NPR-A impact grant to perform an HIA. The goal of the HIA is to aid the NSB in analyzing and understanding potential impacts of proposed development on the health of communities and to design appropriate mitigation measures.

The NSB's HIA contractor, Northern Health Resource Impact Group (NHIRG), has conducted meetings in North Slope communities to present information to various stakeholder and community groups on the HIA program and the baseline community health analysis project. In collaboration with the state-tribal-federal HIA working group, NHIRG drafted guidelines for scoping and public health intervention strategies (DCCED 2009). These HIA efforts are still under review and are on-going.

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