NORTH SLOPE FOOTHILLS AREAWIDE OIL AND GAS LEASE SALES

Final Finding of the Director
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NORTH SLOPE FOOTHILLS
AREAWIDE OIL AND GAS
LEASE SALES

FINAL FINDING OF THE DIRECTOR

Prepared by:
Alaska Department of Natural Resources
Division of Oil and Gas

June 24, 2021
# NORTH SLOPE FOOTHILLS AREAL WIDE OIL AND GAS LEASE SALES

Final Finding of the Director

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Chapter One: Director’s Final Written Finding and Decision

The State of Alaska offers oil and gas leases through a program known as “areawide lease sales” conducted by the Alaska Department of Natural Resources (DNR), Division of Oil and Gas (DO&G). The purpose of areawide leasing is to provide regularly scheduled competitive oil and gas lease sales for available state lands within five specific sale areas that have known hydrocarbon potential: the Alaska Peninsula, Beaufort Sea, Cook Inlet, North Slope, and North Slope Foothills. By conducting lease sales on a regularly scheduled basis, the state has a stable, predictable leasing program, which allows companies to plan and develop their strategies and budgets years in advance. Additionally, the public is afforded a consistent process and timeline during which to comment and provide new information on the proposed areawide lease sales. DO&G is proposing to offer all available state-owned acreage in North Slope Foothills Areawide (Sale Area) oil and gas lease sales to be held from 2021 to 2030.

A. Procedural Background

Under AS 38.05.035(e)(6)(F) and AS 38.05.180, land that is subject to a best interest finding issued within the previous 10 years may be offered for oil and gas leasing each year for up to 10 years. After 10 years, the director of DO&G must renew the areawide analysis, taking a hard look at the topics required under AS 38.05.035(g), including social, economic, environmental, geological, and geophysical information for the proposed lease sale area, and develop a new written finding as part of the areawide best interest finding process. In addition to this 10-year review, DO&G issues annual calls for any substantial new information that has become available since the issuance of the most recent final best interest finding.

In response to annual calls for new information in 2012 to 2020, DO&G received six agency, and seven public replies. In all cases, the submitted new information, while informative, was determined to not justify preparation of a supplement to the 2011 best interest finding. All submitted information was reviewed and considered during preparation of this finding.

On May 5, 2020, DO&G initiated the 10-year review for the Sale Area by issuing a Request for Agency Information to 61 state and federal agency contacts, and 28 borough, city, and village groups. DO&G received replies from DNR’s Division of Forestry and Division of Mining Land and Water (DMLW); Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs; US Fish and Wildlife Service (USFWS); and National Park Service, Gates of the Arctic National Park and Preserve (GAAR).

During May through December 2020, DO&G reached out within DNR and to Alaska Department of Fish and Game (ADF&G), Alaska Department of Environmental Conservation (ADEC), Alaska Department of Transportation and Public Facilities (ADOT&PF), and researchers at the University of Alaska with specific data requests and questions and to solicit reviews of draft chapters. Comments, edits, and data received were incorporated into this finding.

DO&G published the preliminary best interest finding and request for public comments on February 24, 2021 with comments due by April 26, 2021. In response to this request for public comments, DO&G received one response from DNR’s DMLW. DMLW requested a change in language concerning the relationship between ADF&G and DNR with ADEC on the adequacy of spill cleanup in Chapter Six changing “advise” to “coordinate” which was accepted and changing “adequacy of spill cleanup” to “target cleanup endpoints and final cleanup results” which was not
accepted. DMLW also requested two changes to language in mitigation measures in Chapter Nine: changing “frost depth” to “soil temperature” in measure 5.a and replacing the definition for secondary containment in 18 AAC 75.075 with the definition used by DMLW in their authorizations. Neither of these changes were accepted. We retained “snow and frost depths” as a generally accepted phrase for off-road travel conditions to protect the ground surface rather than specifying a particular soil temperature at a specific depth. This maintains consistency for this measure which also occurs in North Slope and Beaufort Sea areawide mitigation measures. DMLW determines when conditions are suitable for wintertime tundra travel. DO&G provided the statutory definition for secondary containment in Section B, which DMLW requested be changed from “containing the volume of the largest independent container” to the definition used by DMLW “containing 110 percent of the largest independent container” to be consistent with DMLW stipulations for land use authorizations. DO&G explained to DMLW, that DO&G defers to ADEC and to the statutory definition of secondary containment as stated in measure 4.a. “The lessee will ensure that secondary containment is provided for the storage of fuel or hazardous substances and sized as appropriate to container type and according to governing regulatory requirements in 18 AAC 75 and 40 CFR 112.”

B. Statement of Applicable Law

The Alaska Constitution directs the state “to encourage… the development of its resources by making them available for maximum use consistent with the public interest” (Alaska Constitution Article VIII, § 1). Moreover, by statute, the people of Alaska have an interest in the development of the state’s oil and gas resources to maximize both the economic and physical recovery of the resources in addition to maximizing competition among parties seeking to explore and develop the resources (AS 38.05.180(a)). The director enables the disposal of lands through the development of written findings under AS 38.05.035(e). The preparation and issuance of written findings by the director are subject to the following:

- AS 38.05.035(e)(1)(A) allows the director to establish the scope of the administrative review on which the director's determination is based, and the scope of the written finding supporting that determination.
- AS 38.05.035(e)(1)(B) allows the director to limit the scope of an administrative review and finding for a proposed disposal to a review of applicable statutes and regulations, and facts pertaining to the land, resources, property, or interest in them that the director finds are material to the determination and are known or available to the director during the administrative review.
- AS 38.05.035(e)(1)(C) allows the director to limit a written finding to the disposal phase.
- AS 38.05.035(h) provides that in preparing a written finding under AS 38.05.035(e)(1), the director may not be required to speculate about possible future effects subject to future permitting that cannot reasonably be determined until the project or proposed use for which a written finding is required is more specifically defined.

Topics to be considered and discussed in written findings under AS 38.05(g)(1)(B) are listed in Chapter Two and are summarized in the analysis.

C. Analysis Summary

In making this final written finding, the director weighed the facts and issues known at the time of this administrative review, considered applicable laws and regulations, and balanced the potential
positive and negative effects after consideration of the proposed mitigation measures and other regulatory guidelines. The director finds that the potential benefits of lease sales outweigh the possible negative effects, and that the North Slope Foothills Areawide oil and gas lease sales will best serve the interests of the State of Alaska. The discussion of these matters is set out in the accompanying chapters of this written finding which are summarized and analyzed here.

1. Sale Area Description

The Sale Area covers about 7.5 million acres bounded on the northwest and west by the National Petroleum Reserve – Alaska (NPR-A), the south by GAAR, the east by the Arctic National Wildlife Refuge (ANWR), and the north by the North Slope Areawide. About 58 percent or 4.4 million acres of the Sale Area are state-owned lands (Figure 1.1). Prominent geographic features in the Brooks Range foothills include long, linear ridges, gently rolling hills, glacial moraines, and mesas composed of tightly folded sedimentary rocks. North Slope communities that use portions of the Sale Area for subsistence activities include Anaktuvuk Pass, Nuiqsut, and Utqiagvik. The Sale Area is divided into 950 lease sale tracts with 820 active tracts containing state-patented or tentatively approved lands and 130 inactive tracts containing state-selected lands. Leasing of oil and gas resources must be by competitive bidding although bidding methods may vary from sale to sale AS 38.05.108(f)(3). About 35 percent of the Sale Area is Native-owned or selected and about 9 percent is federally managed lands that are not included in lease sales.

2. Habitat, Fish and Wildlife

Tundra habitats cover 57 percent of the Sale Area, followed by low and tall shrubs at 26 percent, and freshwaters at 2 percent. Emergent and scrub-shrub wetlands cover about 24 percent of the Sale Area.

Freshwater habitats include tundra, mountain and foothill streams; lakes and seasonal ponds that support a mix of anadromous and freshwater fishes. Many fish in the region move seasonally between overwintering habitats in lakes and river pools; summer foraging habitats in streams, rivers, ponds, lakes, and the nearshore Beaufort Sea; and spawning habitats in streams and rivers. Most key subsistence and sport harvest fishes are long-lived, slow growing, with low fecundity resulting in low population resilience requiring 4.5 to 14 years for population doubling. Population trends are variable with broad whitefish decreasing, chum salmon increasing, Dolly Varden and lake trout stable, and arctic grayling and burbot unknown. Overwintering habitats are critical for sustaining fish populations in the Arctic.

Over 100 species of birds nest on the North Slope. All but a few resident birds are migratory, occurring within the Sale Area primarily during early June through September. The abrupt change in elevation and decrease in wetland habitats from the coastal plain to the foothills, results in generally decreased densities for most waterbirds in the foothills. Waterfowl and ptarmigan support subsistence and sport harvest in the region. Key waterfowl resources include greater white-fronted geese and tundra swans which are increasing and long-tailed ducks which are decreasing in abundance on the coastal plain. Willow ptarmigan are widely distributed across the North Slope, while rock ptarmigan are found primarily in the foothills and mountains. The lower Colville River is a continental important bird area for arctic cliff-nesting raptors including arctic peregrine falcons, gyrfalcons, and rough-legged hawks. Eroding cliff faces provide raptor nesting habitat while the surrounding tundra and riparian areas provide foraging habitat.
Figure 1.1.—General land ownership and lease sale tracts in the Sale Area.
Key wildlife in the Sale Area that support subsistence, and/or local, nonlocal and nonresident hunting and trapping resources are caribou, moose, muskox, Dall sheep, brown bear, wolf, and red fox. Caribou from the Western Arctic (WAH), Teshekpuk (TCH), and Central Arctic (CAH) caribou herds range seasonally across the Sale Area during late summer and spring and fall migrations with some TCH and CAH caribou remaining through winter. Calving ranges for these caribou herds are located outside of the Sale Area. The WAH is currently considered to be declining, while the TCH is increasing, and the CAH is considered stable. Moose, muskoxen, Dall sheep, and wolves have relatively low abundance in the Sale Area. Moose and muskoxen generally concentrate habitat use in riparian areas. Most Dall sheep habitat in the Brooks Range occurs outside of the Sale Area within GAAR and ANWR. On the North Slope brown bear density is generally highest in the foothills, where they frequently use riparian habitats.

3. Current and Projected Uses

State lands within the Sale Area are designated for Resource Management (65 percent), Habitat (14 percent), and combinations of Habitat and Public Recreation-Dispersed with and without Transportation Corridor (19 percent). The current industrial use of the Sale Area is oil and gas transportation (Trans-Alaska Pipeline System and Dalton Highway) with projected industrial use for oil and gas exploration, development, and transportation (natural gas pipeline). Toolik Lake Field Station supports field studies for more than 100 scientists and their students. Use of this site for long-term arctic research is expected to continue and may increase due to road accessibility and if improvements are made to the field station. Lands in the Sale Area have been used for transportation projects including the Hickel and Dalton highways, and for the development of new roads including the Arctic Strategic Transportation and Resources (ASTAR) projects, Community Winter Access Trail (CWAT) to Anaktuvuk Pass, and the Foothills West Transportation Access project from Galbraith Lake to Umiat. High value coal deposits can be found in the Central Slope and Brooks Foothills regions, and while these coal deposits potentially have high commercial and economic value currently there is little interest in these coal resources and interest in not projected to increase.

Driving the Dalton Highway, a state scenic byway, is considered a life-list accomplishment by many recreational visitors. Tourist traffic increased steadily after the highway was opened to the public in 1994 and recreational traffic increased in the Sale Area near Milepost 339 (MP 339) at a rate of 2.4 passenger cars, pickups, vans, and recreational vehicles per week per year between 2009 and 2019. Sale Area recreational visitors were primarily Alaskans, were repeat visitors, and use was highest in August when many visitors hunted for caribou or other game. Recreational use of the Dalton Highway corridor in the Sale Area is projected to continue to increase as ANWR users discover there is direct access to ANWR via the Dalton Highway near Atigun Gorge. During 2010 to 2019, an average of 56 visitors per year accessed ANWR from the Dalton Highway, which increased from 48 per year during the first 5-year period to 63 per year during the second 5-year period.

The primary consumptive use of fish, birds, mammals, and plants of the Sale Area is for subsistence, which broadly refers to any harvest of fish, wildlife, and wild plants for home use as well as noncommercial exchange or sharing. Although Utqiagvik residents use the Colville River for subsistence hunting or fishing, Nuiqsut and Anaktuvuk Pass are the primary communities that use the Sale Area for subsistence. The Sale Area is used to search for and harvest caribou, moose, small mammals, non-salmon fish, and vegetation by Nuiqsut and caribou, small mammals, non-salmon fish, and ducks by Anaktuvuk Pass. The per capita harvest of subsistence foods for these communities shows an increasing trend over time since the 1980s, while populations in these communities have also increased. Increasing trends in subsistence harvest and use by these
communities are expected to continue. Nonlocal and nonresident harvest is a minor component of the overall harvest of game animals within and near the Sale Area because most harvest is for subsistence by local residents. Mean annual harvest of caribou by Utqiagvik, Nuiqsut, and Anaktuvuk Pass from 2014 to 2018 was 4,448 caribou, in comparison, caribou harvest by nonlocal and nonresident hunters in Game Management Units 26A and 26B averaged 829 caribou from 2007 to 2019.

Top fisheries resources harvested by Utqiagvik and Nuiqsut include broad whitefish, cisco, and salmon. Top fisheries resources harvested by Anaktuvuk Pass include Dolly Varden/arctic char, lake trout, and arctic grayling, which overlaps with North Slope sport fish harvest. On average, 60 percent of North Slope freshwater sport fishing effort is concentrated on streams and lakes along the Dalton Highway, with 92 to 100 percent of fish released (lake trout are catch and release only within the Dalton Highway management area). Although an average of about 950 anglers fished freshwaters of the North Slope during the 10-year period, the trend in fishing effort during 2009 to 2018 was declining at a rate of about 243 days fished per year. Like per capita increases in all subsistence resources over time, harvest of freshwater fish by Anaktuvuk Pass shows a slight increasing trend since the 1990s.

4. Oil and Gas in the Sale Area

Except for the Umiat oil accumulation, oil and gas discoveries to date within the Arctic Foothills physiographic region have been primarily dry gas trapped in anticlinal fold closures, identified from early surface geologic mapping and supported by two-dimensional reflection seismic surveys. Formation outcrops and well data corroborate that source rocks in the Arctic Foothills have likely reached advanced thermal maturity due to deep sediment burial, and that major new oil finds are unlikely. Determining petroleum potential requires evaluation of the geology, geophysics, and exploration history, data that are sparsely distributed and dated for the Sale Area. The potential for new discoveries of conventionally recoverable petroleum in the Sale Area is relatively high for gas, and relatively low for oil.

Transportation of oil and gas produced from the Sale Area would likely be through pipelines, with oil pipelines connecting to the Trans Alaska Pipeline System (TAPS). While there is currently no existing transportation system for natural gas, two pipeline options for natural gas transport from North Slope fields to foreign and domestic markets are currently being pursued by the Alaska Gasline Development Corporation. Pipelines are expensive to construct and operation is challenged by cold weather and permafrost. Given the lack of roads and a deep-water harbor on the North Slope, pipelines have been essential for the development and commercialization of Alaska’s crude oil and are likely to continue to be essential for transport of oil and gas from the North Slope.

Oil spill and gas releases are concerns with pipelines, wells, and facilities in the Sale Area. A comprehensive network of agencies, local governmental entities, non-profits, and other organizations are prepared for events in the case a spill or release occurs. In the Sale Area during high flow periods (rain or breakup) effective containment of oil may be limited to the area where oil enters the river and floating ice and aufeis may complicate in-river containment. Tussock tundra, the predominate vegetation type in the Sale Area, complicates treatment because tussocks may preclude the use of heavy equipment because they are easily damaged. The objective of spill cleanup and remediation on tundra is to promote ecological recovery and to prevent effects of cleanup from exceeding those caused by the spill.
5. Governmental Powers to Regulate Oil and Gas

All oil and gas activities are subject to numerous federal, state, and local laws and regulations. Agencies that have broad authority to regulate and condition activities related to oil and gas include Alaska Departments of Natural Resources, Environmental Conservation, and Fish and Game; Alaska Oil and Gas Conservation Commission; US Environmental Protection Agency; US Army Corp of Engineers; US Fish and Wildlife Service; National Marine Fisheries Service; and North Slope Borough.

6. Reasonably Foreseeable Cumulative Effects of Leasing and Subsequent Activity

Activities to be permitted under future oil and gas phases could have reasonably foreseeable cumulative effects on the Sale Area’s habitats, fish and wildlife populations, and subsistence uses. Potential future oil and gas activities could include seismic surveys, construction of support facilities, exploration and development drilling, and construction of drilling and production facilities, roads, and pipelines. Some potential cumulative effects of these activities include physical disturbances that could alter air and water quality; terrestrial, riverine and wetland habitats; landscape connectivity through habitat fragmentation; behavior and habitat use of fish, birds, and mammals; subsistence activities; and terrestrial and freshwater habitats through contamination from pipeline and well drilling spills, gas blowouts, or spills of hazardous substances.

Cumulative effects of oil and gas activities on freshwater habitats and fish are primarily related to altered drainage patterns and water use through construction and use of permanent roads and facilities and gravel mining to build this infrastructure. Gravel roads and gravel mine sites have contributed to impeded fish movements and altered physical and chemical conditions of fish habitat. New facilities are required to be located away from lakes and rivers and stream crossing structures must be designed and maintained to allow fish passage. Water intake structures in fish bearing waters must be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. Dolly Varden overwintering and/or spawning areas are a primary concern in the Sale Area. Specific mitigation measures address siting facilities 1/2 mile away from Dolly Varden overwintering and/or spawning areas; and ensuring that road and pipeline crossing are not located within or would have no effect on these fish or habitats.

Cumulative effects of oil and gas activities on terrestrial habitats and wildlife are primarily related to habitat loss from construction and use of permanent roads, airstrips, facilities, and the associated activity. Because most terrestrial habitats within the Sale Area are tussock tundra and mesic tundra, cumulative effects to terrestrial habitats from seismic surveys are expected to be minor to moderate although most tussock and mesic tundra habitats would be expected to recover within 8 to 10 years. The greatest potential for cumulative effects in the Sale Area is blockage or alteration of caribou movements during migration. Mitigation for pipeline height and separation of roads and pipelines are designed to allow for free passage of caribou. Pre-construction den surveys, improved food waste containment and management, and human-bear interaction plans are required mitigation to avoid and minimize oil and gas impacts on brown bears. Specific wildlife mitigation measures address avoidance of habitat loss; protection of wetland, riparian, and aquatic habitats; disturbance avoidance; and free passage and movement of wildlife. In addition, oil and gas activities may be limited during sensitive periods within important habitats to minimize disturbance; permanent facilities are generally sited away from sensitive habitats and are designed to reduce noise exposure to the surrounding environment.

Oil and gas activities may result in cumulative effects on local subsistence activities, sport fishing, and nonlocal and nonresident hunting primarily through cumulative effects of disruption and
displacement of fish and wildlife resources or harvesters, changes in access that leads to increased
competition among user groups, or by contamination of subsistence resources through spills or
leaks. Participation in subsistence activities has increased from 1977 to 2016 for North Slope
communities, coincident with oil and gas development on the North Slope and the proportion of
subsistence meat and fish consumed by households has remained relatively stable from 2003 to
2016. Most high-use subsistence areas within the Sale Area occur primarily on Native-owned lands
along the Colville, Chandler, and Anaktuvuk rivers. The subsistence activity most likely to be
impacted by oil development in the Sale Area is disruption of caribou hunting through altered
migration patterns, or disturbance from aircraft. Construction of new roads and developments can
change access for nonlocal and nonresident fishers and hunters and if access roads are opened to the
public competition between user groups for fish and wildlife resources could increase. Mitigation
measures address disturbance avoidance, particularly for the fall caribou migration; seismic
activities; siting of facilities; pipelines; oil spill prevention and control; and discharges and waste
from drilling and production. Additional mitigation measures specifically address harvest
interference avoidance, public access, road construction, and oil spill prevention.

Some negative effects related to historic and cultural resources may occur. Mitigation measures
included in this written finding and those developed through permitting in future phases, along with
laws and regulations imposed by state and federal agencies, are expected to mitigate these potential
cumulative effects.

Oil and gas activities may result in fiscal effects on nearby communities and the state. Positive
potential effects are substantial local and state revenues, job creation, and the potential for local use
of oil and gas to lower energy costs. Construction of new roads and developments can increase
overland access for communities that can reduce costs for food, supplies, and equipment. If local
and Alaska residents and contractors are hired for work in the Sale Area the multiplier effect may
benefit local and state economies. Lessees are also encouraged to employ apprentices to work in the
leased area.

7. Mitigation Measures

Mitigation measures address protection of state lands; air and water quality; habitat for fish and
wildlife; local subsistence, and nonlocal and nonresident harvest activities; access; management of
fuels, hazardous substances, and wastes; potential spills of hazardous substances; and siting of
facilities and operations. At the disposal phase, it is unknown whether tracts offered during the
lease sale will receive bids or if leases will be issued for the tracts receiving bids; whether
exploration, development, production, or transportation will be proposed on any leased tract; and
the location, type, size, extent, and duration if subsequent exploration, development, production, or
transportation is proposed. All oil and gas activities conducted under oil and gas leases are subject
to numerous federal, state, and local laws and regulations with which lessees must comply. The
locations and characteristics of the specific tracts that may receive bids in future lease sales may
allow DNR to determine requirements and impacts directly associated with proposed operations on
those tracts. DNR may impose additional requirements necessary to protect the state’s interest
during approval of later phase activities.
**D. Disposal Phase Decision**

The director weighed the facts and issues known at this time and has set out findings. The director considered applicable laws and regulations and balanced the potential positive and negative effects given the mitigation measures and other regulatory protections. Therefore, the director finds that the potential benefits outweigh the possible negative effects, and that the North Slope Foothills areawide oil and gas lease sales will best serve the interests of the State of Alaska.

The state is sufficiently empowered through constitutional, statutory, and regulatory regimes, terms of the lease sale, lease, contract, and plans of operations to ensure lessees conduct their activities safely and in a manner that protects the environment and maintains opportunities for existing and anticipated uses.

A person is eligible to file a request for reconsideration and any subsequent appeal to the Superior Court only if the person has meaningfully participated in this process by submitting written comment during the public comment period.

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**DocuSigned by:**

**Tom Stokes**  
Director, Division of Oil and Gas

I concur with the director that the North Slope Foothills oil and gas lease sales are in the state’s best interest.

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**DocuSigned by:**

**Corri A. Feige**  
Commissioner, Department of Natural Resources
Chapter Two: Introduction

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Chapter Two: Introduction

The Alaska Department of Natural Resources (DNR) is proposing to offer all available state-owned acreage in the North Slope Foothills Areawide oil and gas lease sales area (Sale Area) to be held from 2021 to 2030 (Figure 2.1). This is the director’s final written finding and decision issued under AS 38.05.035(e). It discusses whether the interests of the state will be best served through the disposal of interests in state oil and gas through lease sales in the Sale Area.

A. Constitutional Authority

The Alaska Constitution provides that the general policy of the state is “to encourage…the development of its resources by making them available for maximum use consistent with the public interest” and that the “legislature shall provide for the utilization, development, and conservation of all natural resources belonging to the State…for the maximum benefit of its people” (Alaska Constitution, Article VIII, §§ 1 and 2). The legislature has been empowered to make all policy decisions to carry out these general goals, as well as to provide the policies and procedure for the lease, sale, and granting of state-owned land (Alaska Constitution, Article VIII, §§ 8, 9, and 12). The Alaska Land Act guides the land management and disposal policy of the state. The Act, codified at AS 38.05, provides the DNR commissioner the authority to select, manage, and dispose of state lands, and directs DNR to implement the requisite statutes.

The legislature has found that the people of Alaska have an interest in the development of Alaska’s oil and gas resources to maximize the economic and physical recovery of the resources, maximize competition among parties seeking to explore and develop the resources, and maximize use of Alaska’s human resources in the development of the resources. It is in the state’s best interest to encourage an assessment of its oil and gas resources and to allow the maximum flexibility in the methods of issuing leases to recognize the many varied geographical regions of the state and the different costs of exploring for oil and gas in these regions, and to minimize the adverse impact of exploration, development, production, and transportation activity. Further, it is in the best interests of the state to offer acreage for oil and gas leases or for gas only leases, specifically including state acreage that has been the subject of a best interest finding at annual areawide lease sales (AS 38.05.180(a)(1)–(2)). Division of Oil and Gas (DO&G) has identified five areas of moderate to high potential for oil and gas development and designated these areas, including the North Slope Foothills Areawide, for leasing through competitive oil and gas sales.
Figure 2.1.—Map of the North Slope Foothills Areawide lease sales area with tracts.
B. Written Findings

Alaska statutes govern the disposal of state-owned mineral interests. Under AS 38.05.035(e), the director may, with the consent of the commissioner, dispose of state land, resources, property, or interests after determining in a written finding that such action will serve the best interests of the state. The written finding is known as a “best interest finding” and describes the proposed Sale Area, considers and discusses the potential effects of the lease sales, describes measures to mitigate those effects, and constitutes the director’s determination whether the interests of the state will be best served by the disposal. DO&G issues both a preliminary written finding and a final written finding, providing opportunity for public comment after the preliminary finding is released. This final written finding includes a discussion of material issues raised during the public comment period, as well as a summary of the comments received (Chapter One).

1. Applicable Law and Facts

The best interest finding requirements outlined in AS 38.05.035 provide DNR with procedures to ensure Alaska’s resources are developed for the maximum benefit of the state as mandated by Article VIII, § 2 of the Alaska Constitution. The authorities applicable to this written finding include the requirements and procedures set out in AS 38.05.035(e)-(m), and the case law applicable to the disposal phase.

Under AS 38.05.035(e), the director may not dispose of state land, resources, or property, or interests therein, unless the director first determines in a written finding that such action will serve the best interests of the state. The provisions in AS 38.05.035(e) set out the scope of review and process for the written finding.

The statute also expressly empowers DNR to review projects in phases, allowing the analysis of proposed leasing to focus on the issues pertaining to the disposal phase and the reasonably foreseeable significant effects of leasing (AS 38.05.035(e)(1)(C)). Further explanation of the statutory direction is provided in the sections below. The regulatory authorities governing exploration, development, production, and transportation of oil and gas development are discussed further in Chapter Seven.

2. Scope of Review

As required by AS 38.05.035(e)(1)(A)–(C), the director, in the written finding:

- shall establish the scope of the administrative review on which the director’s determination is based, the scope of the written finding supporting that determination, and the scope of the administrative review and finding may only address reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal;

- may limit the scope of an administrative review and finding for a proposed disposal to a review of (1) applicable statutes and regulations, (2) facts pertaining to the land, resources or property, or interest in them that are material to the determination and known to the director or knowledge of which is made available to the director during the administrative review, and (3) issues that, based on the applicable statutes, regulations, facts, and the nature of the uses sought to be authorized by the disposal, the director finds are material to the determination of whether the proposed disposal will serve the best interests of the state; and

- may, if the project for which the proposed disposal is sought is a multi-phased development, limit the scope of an administrative review and finding for the proposed
disposal to the applicable statutes, and regulations, facts and issues that pertain solely to the
disposal phase of a project when the conditions of AS 38.05.035(e)(1)(C)(i)–(iv) are met.

a. Reasonably Foreseeable Effects
The scope of this administrative review and finding addresses only the reasonably foreseeable,
significant effects of the uses proposed to be authorized by the disposal (AS 38.05.035(e)(1)(A)).

A detailed discussion of the possible effects of unknown future exploration, development, and
production activities is not within the scope of this best interest finding. Therefore, the director has
limited the scope of this finding to the applicable statutes and regulations, facts, and issues
pertaining solely to the Sale Area, and the reasonably foreseeable significant effects of the North
Slope Foothills Areawide lease sale disposals. However, this finding does discuss potential
cumulative effects, in general terms, that may occur with oil and gas activities related to lease sales,
exploration, development, production, and transportation within the Sale Area and any mitigation
measures in the lease terms as required by AS 38.05.035(g)(1) and (2).

b. Matters Considered and Discussed
In a preliminary or final written finding, the director must consider and discuss facts related to
topics set out under AS 38.05.035(g)(1)(B)(i)–(xi) that are known at the time the finding is being
prepared. The director must also consider public comments during the public comment period and
within the scope of review set out in Sections A and B.1–2 of this chapter.

This document is organized for ease of reading and reviewing and does not necessarily follow the
order as found in AS 38.05.035(g)(1)(B) (Table 2.1).
Table 2.1.—Topics required by AS 38.05.035(g)(1)(B).

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c. Review by Phase

The director may limit the scope of an administrative review and finding for a proposed disposal to evaluate the potential effects of the proposed disposal when the director has sufficient information and data available upon which to make a reasoned decision.

Under AS 38.05.035(e)(1)(C), if the project for which the proposed disposal is sought is a multi-phased development, the director may limit the scope of an administrative review and finding for the proposed disposal to the applicable statutes and regulations, facts, and issues identified above pertaining solely to the disposal phase of the project under the following conditions:

i. the only uses to be authorized by the disposal are part of that phase;
ii. the disposal is a disposal of oil and gas, or of gas only, and, before the next phase of the project may proceed, public notice and the opportunity to comment are provided under regulations adopted by the department;
iii. the department’s approval is required before the next phase may proceed; and
iv. the department describes its reasons for a decision to phase.
Here, the director has met condition (i) because the only uses authorized are part of the disposal phase. The disposal phase is the lease sale phase of a project. As defined in *Kachemak Bay Conservation Society v. State, Department of Natural Resources*, “disposal” is a catch all term for all alienations of state land and interests in state land.\(^1\) In *Northern Alaska Environmental Center v. State, Department of Natural Resources*, the court further held that a disposal was a conveyance of a property right.\(^2\) For an oil and gas development project, the lease is the only conveyance of property rights DNR approves. The lease gives the lessee, subject to the provisions of the lease and applicable law the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances, as well as the nonexclusive right to conduct within the leased area geological and geophysical exploration for oil, gas, and associated substances, the nonexclusive right to install pipelines and build structures on the lease area to find, produce, save, store, treat, process, transport, take care of, and market all oil and gas and associated substances, and to house and board employees in its operations on the lease area. While the lessee has these property rights upon entering into the lease, the lease itself does not authorize any oil and gas activities on the leased tracts without further permits from DNR and other agencies. There are no additional property rights to be conveyed at later phases.

Condition (ii) is met, first, because the disposal is for the sale or lease of available land or an interest in land, for oil and gas, or for gas only, scheduled in the oil and gas leasing program under AS 38.05.180(b). Condition (ii) is also met because public notice and opportunity to comment are provided for each phase of a project. Public notice and the opportunity to comment on the disposal phase of a new 10-year areawide best interest finding is provided through the preliminary best interest finding under AS 38.05.035(e)(5), AS 38.05.945, and 11 AAC 82.415. Subsequent post-disposal phases may not proceed unless public notice and the opportunity to comment are provided under regulations adopted by DNR. DNR provides public notice and opportunity to comment for plans of operation that initiate a new phase under 11 AAC 83 as authorized by AS 38.05.

Condition (iii) is met because DNR’s approval is required before the next phase may proceed.

Condition (iv) is met by the findings in Chapter One discussing the speculative nature of current information on where leases may be sold within the Sale Area, what future development projects and methods may be proposed that would require post-disposal authorizations; and what permit conditions and mitigation requirements will be appropriate for authorizations at later phases.

This preliminary best interest finding satisfies the requirements for phased review under AS 38.05.035(e)(1)(C).

### 3. Process

The process of developing a best interest finding includes opportunities for input from a broad range of participants, including the public; state, federal, and local government agencies; Alaska Native organizations; resource user groups; non-governmental organizations (NGOs); and any other interested parties.

#### a. Request for Agency Information and Preliminary Finding

The process for receiving public input begins with a request for information from state and federal agencies, and local governments. DO&G requests information and data about the region’s property ownership status, peoples, economy, current uses, subsistence, historic and cultural resources, fish and wildlife, and other natural resource values. Using this information and other relevant

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\(^1\) 6 P.3d 270, 278 n.21 (Alaska 2000).

\(^2\) 2 P.3d 629, 635-36 (Alaska 2000).
information that becomes available, DO&G develops a preliminary best interest finding and releases it for public comment. Information received, and responses to formal and informal requests for agency input is summarized in the following paragraphs (AS 38.05.035(e)(7)(A)).

On May 5, 2020, DO&G issued a Request for Agency Information to initiate the process of gathering information to determine if it is in the state’s best interest to conduct the proposed lease sale disposals within the North Slope Foothills Areawide from 2021 to 2030. The Request for Agency Information was sent via email to 61 state and federal agencies, and via email or mail to 28 borough, city, and village groups. The comment period ran from May 5, 2020 to August 5, 2020. Agencies were encouraged to submit comments and information within this commenting period. DO&G received replies from DNR’s Division of Forestry and Division of Mining Land and Water; Alaska Department of Commerce, Community, and Economic Development, Division of Community and Regional Affairs; US Fish and Wildlife Service; and National Park Service, Gates of the Arctic National Park and Preserve in response to the Request for Agency Information.

DO&G reached out both within DNR and to Alaska Department of Fish and Game, Alaska Department of Environmental Conservation, Alaska Department of Transportation and Public Facilities, and researchers at the University of Alaska with specific questions and data requests and to solicit agency review of draft chapters during May through November 2020. Comments, data, and edits received were used to develop the preliminary finding.

b. Request for Public Comments

Once a preliminary best interest finding is issued, DO&G follows AS 38.05.945(a)(3)(A)–(b)(2) to solicit public comments. This statute includes specific provisions for public notice for written findings for oil and gas lease sales under AS 38.05.035(e).

Public comments assist in developing information for the final best interest finding. Information provided by agencies and the public assists the director in determining which facts and issues are material to the decision of whether the proposed lease sales are in the state’s best interest, and in determining the reasonably foreseeable, significant effects of the proposed lease sale. Summaries of these comments and the director’s responses are published in the final best interest finding (AS 38.05.035(e)(7)(B)).

c. Final Finding

After receiving public comments on the preliminary best interest finding, DO&G reviews all comments and incorporates additional relevant information and issues into the final best interest finding. DO&G will also include a summary of comments received during the public comment period. After considering the information, laws, comments, and issues material to the determination and made available during the administrative review, the director with the consent of the commissioner, makes a determination and develops a final written finding which is co-signed by the commissioner. The final best interest finding will be issued at least 90 days before the 2021 North Slope Foothills Areawide lease sale (AS 38.05.035(e)(5)(B)).

d. Requests for Reconsideration

A person who is aggrieved by the final best interest finding who provided timely written comment on this decision may request reconsideration, in accordance with 11 AAC 02. Any request for reconsideration must be received within 20 calendar days after the date of issuance of the final best interest finding, as defined in 11 AAC 02.040(c) and (d) and may be mailed or delivered to the Commissioner, Department of Natural Resources, 550 W. 7th Avenue, Suite 1400, Anchorage, Alaska 99501; faxed to 1-907-269-8918, or sent by electronic mail with payment of the $200 fee to dnr.appeals@alaska.gov. If reconsideration is not requested by that date or if the commissioner
does not independently order reconsideration, the final best interest finding will go into effect as a 
final order and decision on the 31st calendar day after issuance.

Failure of the commissioner to act on a request for reconsideration within 31 calendar days after 
issuance of the final best interest finding is a denial of reconsideration and is a final administrative 
order and decision for purposes of an appeal to Superior Court. That decision may then be appealed 
to Superior Court within 30 days in accordance with the rules of the court, and to the extent 
permitted by applicable law. An eligible person must first request reconsideration of the final best 
interest finding in accordance with 11 AAC 02 before appealing that decision to Superior Court. A 
copy of 11 AAC 02 may be obtained from any regional information office of the Department of 
Natural Resources.

C. Annual Lease Sales

Under AS 38.05.035(e)(6)(F) and AS 38.05.180, once a final best interest finding has been issued 
for an areawide lease sale, DOI&G may hold competitive areawide lease sales under 
AS 38.05.035(e) and AS 38.05.180. Under these statutes, land that is subject to a best interest 
finding issued within the previous 10 years may be offered for oil and gas leasing each year for up 
to 10 years without repeating this comprehensive best interest finding review process. However, 
before holding a sale, DOI&G will determine whether a supplement to the finding is required 
through the Call for New Information process.

1. Calls for New Information

Approximately 9 months before a lease sale, DOI&G issues a Call for New Information requesting 
substantial new information that has become available since the most recent final finding for that 
Sale Area. This request is publicly noticed and provides opportunity for public participation for a 
period of not less than 30 days. After evaluating the information received, the director will 
determine if it is necessary to supplement the final finding and will either issue a supplement to the 
finding or a Decision of No New Substantial Information no less than 90 days before the sale. The 
supplement has the status of a final best interest finding and is subject to an administrative appeal 
or a request for reconsideration.

Mitigation measures developed in this North Slope Foothills Areawide best interest finding will be 
attached to leases sold during the term of the finding unless, as a result of new information, the 
director deems it necessary to change some of the measures or create additional ones.

2. Bidding Method and Lease Terms

AS 38.05.180(f) and 11 AAC 83.100(a) require competitive bidding for oil and gas leases. For each 
lease sale under the final North Slope Foothills Areawide best interest finding, the commissioner 
will adopt the bidding method(s) and terms under AS 38.05.180 that the commissioner determines 
are in the state’s best interest. In selecting the bidding method for each North Slope Foothills 
Areawide oil and gas lease sale, DOI&G considers and balances the following state interests: 
protecting the state’s ownership interest in hydrocarbon resources, promoting competition among 
those seeking to explore and develop the area, encouraging orderly and efficient exploration and 
development, and the need to generate revenue for the state.

Leasing of oil and gas resources under AS 38.05.180(f) and 11 AAC 83.100 must be by 
competitive bidding, but bidding methods may vary from sale to sale. Following a pre-sale analysis, 
the commissioner may choose from the bidding methods listed in AS 38.05.108(f)(3):
• a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease;

• a cash bonus bid with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease and a fixed share of the net profit derived from the lease of not less than 30 percent reserved to the state;

• a fixed cash bonus with a royalty share reserved to the state as the bid variable but no less than 12.5 percent in amount or value of the production removed or sold from the lease;

• a fixed cash bonus with the share of the net profit derived from the lease reserved to the state as the bid variable;

• a fixed cash bonus with a fixed royalty share reserved to the state of not less than 12.5 percent in amount or value of the production removed or sold from the lease with the share of the net profit derived from the lease reserved to the state as the bid variable;

• a cash bonus bid with a fixed royalty share reserved to the state based on a sliding scale according to the volume of production or other factor but in no event less than 12.5 percent in amount or value of the production removed or sold from the lease;

• a fixed cash bonus with a royalty share reserved to the state based on a sliding scale according to the volume of production or other factor as the bid variable but not less than 12.5 percent in amount or value of the production removed or sold from the leases.

Not later than 45 days before the lease sale, DO&G issues a public notice describing the tracts to be offered, the location and time of the sale, and the terms and conditions of the sale (AS 38.05.035(e)(6)(F)(ii)). The announcement may include information such as a tract map showing generalized, unofficial land status, estimated tract acreages, and instructions for submitting bids. The lease sale process consists of opening and reading the sealed bids and awarding a lease to the highest bid per acre by a qualified bidder on an available tract. DO&G verifies the state’s ownership interest only for the acreage within the tracts that receive bids. Only those state-owned lands within the tracts that are determined to be free and clear of title conflicts are available to lease. DO&G reserves the right to defer potential lease sale tracts at any point up to lease award.

3. Lease Adjudication and Lease Award

The Sale Area is divided into lease sale tracts. The extent of the state’s ownership interest within tracts is generally not determined before a lease sale. Instead, following each lease sale, and before awarding leases, DO&G will verify land available for leasing and acreage within tracts receiving bids. Determination of a lease award may take several months following a lease sale depending on the number of tracts receiving bids and the complexity of lease history and ownership within the tract. DO&G may determine that no lands within a tract are available for leasing and issue a notice of no award. Reasons for this may include a determination that lands within a tract are not state-owned, are subject to an existing oil and gas lease, clouded by title claims, within tracts deferred or deleted from sale, subject to pending applications or administrative appeals or litigation, or otherwise determined by DO&G to be unavailable for leasing. Further, DO&G reserves the right to defer or delete acreage or tracts from the sale at any time up to lease award. Should a potential bidder require land title, land status, or survey status information for a tract before submitting a bid, it will be the bidder’s responsibility to obtain that information from DNR and federal public land records.
Chapter Three: Sale Area Description

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Chapter Three: Sale Area Description

AS 38.05.035(g)(1)(B)(i) requires that the director consider and discuss the property descriptions and locations of the North Slope Foothills Areawide oil and gas lease sale area (Sale Area). The following overview includes information material to the determination of whether lease sales in this area will best serve the state’s interest (AS 38.05.035(e)(1)(B)(iii)). It is not intended to be all inclusive.

A. Location and General Description

The Sale Area covers about 7.5 million acres on the foothills of the Brooks Range and the arctic coastal plain between the National Petroleum Reserve – Alaska (NPR-A) on the north and west, the Arctic National Wildlife Refuge (ANWR) on the east and south, the Umiat Meridian Baseline on the north, and the Gates of the Arctic National Park and Preserve (GAAR) on the south (Figure 3.1). One Legislatively Designated Area, the Dalton Highway Corridor (AS 19.40) occurs within the Sale Area.

Prominent geographic features in the Brooks Range foothills include long, linear ridges, gently rolling hills, glacial moraines, and mesas composed of tightly folded sedimentary rocks (ADF&G 2006, 2015). In the Sale Area a few of these include: Outpost Mountain, Pingaluligit Mountain, Kakukturat Mountain, Grandstand Ridge, Rooftop Ridge, Shale Wall Bluff, Niakogon Buttes, and Hatbox Mesa. The eastern third of the Sale Area is crossed by the Dalton Highway and the Trans-Alaska Pipeline System (TAPS) that run through the Sagavanirktok River valley before crossing to the Kuparuk and Atigun river valleys. TAPS pump stations 3 and 4 are in the Sale Area. The Hickel Highway, a RS2477 trail, follows the Anaktuvuk River valley from the village of Anaktuvuk Pass through the Sale Area. Continuous thick permafrost impedes drainage and wetlands predominate throughout the region. Lakes are less common in the foothills than on the coastal plain, although there are several large lakes near the southern border of the Sale Area including Toolik Lake and Galbraith Lake. Some rivers freeze solid in winter, but many are spring-fed, creating large aufeis deposits that last well into summer (ADF&G 2006, 2015). Many streams and rivers originating in the Brooks Range cross through the Sale Area including the Colville, which comprises over 40 percent of the northern Sale Area boundary, Killik, Chandler, Anaktuvuk, Nanushuk, Itkillik, Kuparuk, Toolik, Sagavanirktok, and Ivishak rivers (Figure 3.1).

The Sale Area is entirely within the North Slope Borough (NSB) and the Division of Oil and Gas (DO&G) divides the Sale Area into 950 tracts ranging in size from 240 to 6,250 acres, of which 820 tracts contain state-patented or tentatively approved lands. An additional 130 tracts contain state-selected lands. About 35 percent of the Sale Area is Native-owned or Native-selected lands that are not included in lease sales.

B. Land and Mineral Ownership

The Alaska Statehood Act granted to the State of Alaska the right to select over 102.5 million acres of land from the federal public domain to serve as an economic base for the new state. The Statehood Act also granted to Alaska the right to all minerals underlying these selections and specifically required the state to retain this mineral interest when conveying its interests in the land (AS 38.05.125). Accordingly, when state land is conveyed to an individual, local government, or other entity, state law requires that the deed reserve the mineral rights for the state unless there is a prior, valid claim. The Statehood Act provided for the US Submerged Lands Act to apply to Alaska. The US Submerged Lands Act sought to return title of submerged lands to the states and in the Sale Area would apply to navigable rivers although none of the rivers that cross through the Sale Area are considered navigable.
Figure 3.1.—Geographic features in the Sale Area.
The Alaska Native Claims Settlement Act (ANCSA), passed by Congress in 1971, granted regional Native corporations the right to select and obtain land and mineral estates from the federal domain within the regional Native corporation boundaries. The Sale Area is within the boundary of one Native regional corporation, Arctic Slope Regional Corporation (ASRC), which owns nearly 5 million acres of land in Northern Alaska (ASRC 2020). No Native villages occur within the Sale Area. Villages closest to the Sale Area are Anaktuvuk Pass (Nunamiut Corporation) and Nuiqsut (Kuukpik Corporation). Village corporations are entitled to the surface estate and ASRC is entitled to the mineral estate of ASRC lands in the Sale Area. The federal government continues to convey selected lands. Estimated surface ownership and pending selections for lands within the Sale Area are listed in Table 3.1 and shown in Figure 3.2. The Bureau of Land Management (BLM) retains management of selected and other lands that cover about 9 percent of the Sale Area.

There are eight parcels of which the surface estate was conveyed from the state through the federal government to Native allottees. The NSB is also entitled to land through the state’s municipal entitlement program. Municipal conveyances are pending within the lease sale area. For the most part, the state, as the owner of the retained mineral estate, may lease these lands for oil and gas development.

Should lands where the surface is owned by an entity other than the state be offered and leased by the State of Alaska, rights to explore and develop oil and gas resources may not be exercised until the lessees make provisions to compensate the landowner for full payment for all damages sustained by the owner, by reason of entering upon the land, as required by leases and AS 38.05.130 as applicable. Mineral closing orders, which are commonly associated with surface land disposal, do not apply to oil and gas leasing. The Sale Area contains tracts in which the state owns both the land estate and the mineral estate. Only those free and unencumbered state-owned oil and gas mineral estates within the tracts will be included in any lease issued.

Table 3.1.—General land ownership in the Sale Area.

<table>
<thead>
<tr>
<th>General Land Ownership</th>
<th>Approximate Area (acres)</th>
<th>Proportion of Sale Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Patent, Interim Conveyed, Allotments</td>
<td>2,473,351</td>
<td>33%</td>
</tr>
<tr>
<td>Native Selected</td>
<td>124,197</td>
<td>2%</td>
</tr>
<tr>
<td>State Patent, Tentatively Approved</td>
<td>4,359,866</td>
<td>58%</td>
</tr>
<tr>
<td>State Selected</td>
<td>326,848</td>
<td>4%</td>
</tr>
<tr>
<td>Bureau of Land Management, Managed</td>
<td>654,113</td>
<td>9%</td>
</tr>
</tbody>
</table>

Note: Approximately 0.1% of Sale Area has both Native and state selections.
Figure 3.2.—General land ownership in the Sale Area.
C. Historical Background

1. Prehistory

The North Slope arctic coast served as a migration corridor for groups arriving from Asia across the Bering land bridge. Evidence of human occupation and use of the arctic coastal plain dates back to 13,200 years ago (Goebel et al. 2008). The Beringian populations began exploring the Brooks Range foothills when glaciers began retreating to the Brooks Range. The Paleoindian period between 9,800 and 13,700 years ago, is the first widespread Native American cultural tradition well documented by the archaeological record. These groups were likely small, mobile bands that hunted large game. As the environment changed at the end of the Pleistocene era, and the large Ice Age mammals disappeared, the Paleoindian lifeways disappeared from arctic Alaska’s archaeological record (Kunz et al. 2003; Raff et al. 2015). The Mesa site, south of Utqiaġvik in the foothills of the Brooks Range, is the best documented site of the period (Kunz and Reanier 1995).

Human groups adapted to the post-glacial period and the absence of large land mammals. Evidence of human habitation and hunting along the upper Colville River dates to about 7,670 years before present (BP). Evidence of habitation found at Anaktuvuk Pass dates to about 6,560 years BP. Researchers have noted the complexities in following populations from this area, with evidence suggesting the movement of coastal inhabitants inland toward the Brooks Range and vice versa (Anderson 1984). Movement of inhabitants from the Noatak/Kobuk river region after 600 years BP resulted in occupation of the Brooks Range and Colville Basin (Hall 1984). The inhabitants of the Brooks Range were known as Nunamiut, derived from the Inupiaq for nuna ‘land’ and miut ‘people of’. Maximizing hunting capabilities, mutual aid and building trading relationships characterize the social organizations of populations in this region. For inhabitants of the mountains, caribou was the primary component of their lifestyle, constituting more than 90 percent of the diet, clothing and shelter (Hall 1984).

2. Historic and Cultural Resources

Cultural resources generally include sites, buildings, structures, objects, and districts. These cultural resource types include: lithic scatters, tent camps, cairns, weirs, historic roads, and historic military buildings. These items provide information pertaining to the precontact and historic culture of people throughout Alaska. Known sites identified across the North Slope consist of sod houses, graves, storage pits, ice cellars, bones, and artifacts. These sites represent land use of the area by a variety of precontact and historic groups, including Nunamiut, other Inupiat, and Euro-American populations.

Previously recorded cultural resource sites, culturally sensitive areas, and known paleontological sites include those identified in the Alaska Heritage Resources Survey (AHRS), the National Register of Historic Places (NRHP), the NSB Traditional Land Use Inventory (TLUI), by the Commission on Inupiat History, Language and Culture, and sites identified in other published studies. These databases are not exhaustive and are continually being updated with both new and revised information. The AHRS and TLUI are comprised of restricted access documents and specific site location data will not be published in this finding or distributed to others.

The AHRS database is maintained by the Alaska Office of History and Archaeology (OHA) and indicates that there are approximately 800 known historic and archaeological sites within the Sale Area (AHRS 2020). Many of these cultural resource locations consist of lithic scatters, tent rings, and paleontological locations. Other site types include cairns, ceramic sites, hearths, and fish weir locations. Most locations are small and hard to readily identify. Some locations, such as village locations along the tributaries of the Colville River, continue to be used today. Historic cultural
resource sites are much less prevalent, but those that have been recorded include historic artifact
scatters, drill rigs, utilitarian structures, and resource exploration equipment.

Only a small portion of the state has been surveyed for cultural resources to date. Lessees are
advised that previously unidentified resources may be located within the Sale Area. Inadvertent
cultural resources discoveries made during construction or operation on Sale Area parcels should be
reported to OHA (for state land) and/or the appropriate landowner. Depending on the discovery and
the location, OHA may require that further work be completed at the location before operations can
continue.

3. Recent History

The environmental characteristics of the Arctic shaped Inupiat culture into a semi-nomadic society
with a tradition of whaling and an emphasis on seasonal inland hunting. This pattern of land use
remained unchanged until the second half of the 19th century with the arrival of westerners and
new tools and other natural events such as a natural decline in the caribou population (Kunz et al.
2003; Whitridge 2004). North Slope Inupiat traded with Asia across the Bering Strait as early as the
mid-1700s (Langdon 1996). Canadian and Alaska Inupiat established trading centers at the mouth
of the Colville River and Barter Island. European explorers and fur traders began arriving in Arctic
Alaska in the 1820s and 1830s. This contact introduced metal tools, traps, and guns to support
trading and hunting. Russian trading posts were established from Norton Sound southward (Kunz et
al. 2003; Darigo et al. 2007).

The discovery of bowhead whale migration routes led to an increase in commercial whaling activity
between 1850 and 1890. Several whaling stations were built along the coast and provided regular
contact and trading with the Inupiat population. Steamships replaced sailing vessels facilitating
year-round access. During the final quarter of the nineteenth century, smallpox and influenza
outbreaks decimated North Slope Inupiat populations (Darigo et al. 2007; Bell 2016). A
simultaneous decline in caribou populations resulted in famine and caused inland Inupiat to relocate
to coastal communities, such as Utqiagvik (Langdon 1996). By 1910, the population decline
reduced the Inupiat population to between 20 and 25 percent of its 1850 population (Langdon
1996). A few families returned to the area along the Killik River and Chandler Lake around 1938,
and a permanent community was established at Anaktuvuk Pass in the early 1950s (Hall 1984;
DCCED 2020a).

In 1900, a report by the US Navy provided the first written documentation about petroleum
resources on land inshore from the Sale Area by verifying oil shale deposits along the Etivluk
River. The US Geological Survey (USGS) completed the first comprehensive survey within what
would later become the National Petroleum Reserve – Alaska in 1901 and published the results in
1904. The USGS report noted the presence of geological formations that could have petroleum
deposits as well as natural oil seeps near Cape Simpson. The federal government began exploring
for oil in 1923 with the establishment of the Naval Petroleum Reserve No. 4 (Reed 1958).

The contemporary period of change for the North Slope began in the late 1960s. The discovery of
the Prudhoe Bay oilfield in 1968 prompted a renewed interest in petroleum exploration and
development (Darigo et al. 2007). Development of the Prudhoe Bay oilfield began in 1969, and
construction of TAPS began after congressional approval of the right-of-way in 1973. Construction
of TAPS provided a transportation system that has allowed for the incremental growth of a network
of developed oilfields with interconnecting roads and pipelines across the North Slope (NRC 2003).
D. Communities

The Sale Area lies within the NSB, a non-unified home rule borough incorporated in 1972, whose boundaries extend from the Chukchi Sea to the Canadian border and include the entire North Slope of Alaska. NSB is the largest borough in Alaska covering about 89,000 square miles of land, or about 15 percent of the state’s total land area (DCCED 2020b). The Home Rule Charter adopted in 1974 allows NSB to exercise legal governmental powers in addition to its power of taxation, property assessment, education, and planning and zoning services. The borough government consists of an elected mayor, an eleven-member assembly, a seven-member school board, and an eight-member planning commission (NSB 2019a). NSB serves as the regional government for the eight villages within its boundary: Anaktuvuk Pass, Atqasuk, Kaktovik, Nuiqsut, Point Hope, Point Lay, Utqiagvik, and Wainwright. As the regional government, NSB is responsible for providing public works, utilities, health, and other public services for these villages.

All North Slope communities have federally-recognized tribal governments, and each village has an active tribal council. In addition to the local governing bodies, there are two regionally active tribal organizations. The Inupiat Community of the Arctic Slope (ICAS) is a federally-recognized tribal organization and aids villages in areas of realty, transportation, and resource management programs. The Arctic Slope Native Association (ASNA) has been active in the NSB for many years, but the primary foci of the organization in recent years are healthcare and social services. In addition, Maniilaq Association (Kotzebue) and Tanana Chiefs Conference (Fairbanks) provide health and social services in some borough villages.

The 2019 NSB population was 17,189, with 8,638 permanent residents in eight communities, and 8,551 transient oil field workers that spend at least half of the calendar year in the North Slope oil fields (NSB 2019a). About 54 percent of the NSB population in 2016 was American Indian and Alaska Native (DOLWD 2016c). An analysis of NSB oil field workforce for 2016 shows that 18 percent were local workers, 47 percent lived elsewhere in Alaska, and 35 percent lived outside of Alaska (Fried 2018). NSB employment decreased by nearly 2,000 jobs between 2011 and 2018, with the largest decrease in oil and gas industry jobs (natural resource/mining) and the largest increases in local government and professional/business services (Figure 3.3). The NSB is supported primarily (88 percent of fiscal year 2019 budget) by property taxes with most of these taxes on oil industry facilities. In 2019, revenues from oil and gas related property taxes totaled over $375 million and accounted for more than 95 percent of the borough’s total tax levy (NSB 2019b).
Chapter Three: Sale Area Description

Figure 3.3.—Comparison of 2011 and 2018 North Slope Borough employment.

Most North Slope communities are accessible only by air, and air travel is the primary means of year-round long-distance transportation. One airline provides passenger service between Utqiagvik and the state’s largest cities, and smaller commuter airlines travel between Utqiagvik and the villages (NSBSD 2018). Communities in the NSB tend to be very spread apart. Distances between communities vary from 58 miles between Utqiagvik and Atqasuk to 588 miles between Kaktovik and Point Hope. The 414 mile Dalton Highway is the only all-season road connecting the NSB to Fairbanks and the Alaska Highway system (BLM 2015b). The North Slope is home to Alaska’s major oil production facilities at Prudhoe Bay (DOLWD 2018a). Communities that use portions of the Sale Area for subsistence activities include Anaktuvuk Pass, Nuiqsut, and Utqiagvik.

1. Anaktuvuk Pass

Anaktuvuk Pass is located at 2,200 feet elevation on the divide between the Anaktuvuk and John rivers in the central Brooks Range. Anaktuvuk Pass is located on a historic caribou migration route and is the last remaining settlement of the Nunamiut, the inland northern Inupiat. The area encompasses 4.80 square miles of land and 0.10 square miles of water (WHPacific 2015; DCCED 2016). Anaktuvuk Pass is 250 miles southeast of Utqiagvik, and 250 miles northeast of Fairbanks. Anaktuvuk Pass is outside of the southern boundary of the Sale Area, but residents use the Sale Area for subsistence. Anaktuvuk Pass was originally incorporated as a fourth-class city in 1959 and was incorporated as a second-class city in 1971. The City of Anaktuvuk Pass is managed by the mayor, and a seven-person city council provides local governance. The Mayor is also a member of the council (WHPacific et al. 2016). The seven-member Nagsragmiut Tribal Council governs the Village of Anaktuvuk Pass, a federally-recognized tribe established under authority of the Indian Reorganization Act (IRA) of 1934. The Nagsragmiut Tribal Council is a member of the ICAS regional tribal government (WHPacific et al. 2016).

In 2018, the estimated population for Anaktuvuk Pass was 376, and 87 percent of the population was Alaska Native or American Indian. The economy is mixed with harvest of local food, barter for services, sharing of food and services, corporation dividend incomes, permanent fund dividend income, and wage labor (WHPacific et al. 2016). In 2018, the estimated median household income was $54,375; median family income was $63,750; with about 19 percent of Anaktuvuk Pass’s population estimated to be below the poverty level (DCCED 2020a). Local government is the main
industry in Anaktuvuk Pass, employing nearly 77 percent of the total workforce 2016 (DOLWD 2016a).

A gravel airstrip is owned and operated by the NSB and provides Anaktuvuk Pass with year-round access. Several airlines service the community, providing passenger, freight, and mail service. There are approximately 8 miles of developed, gravel roads in Anaktuvuk Pass and approximately 3 miles of trails leading to the subsistence/recreation area north of the village. While there are no permanent roads leading to Anaktuvuk Pass, cargo has historically been transported in the winter via an ice road that connects to the Dalton Highway (WHPacific et al. 2016).

The NSB school district operates the Nunamiut School which provides education from pre-kindergarten through grade 12. Including preschool students, enrollment at the Nunamiut School averaged 87 students, with a low of 67 students during the 2003/2004 school year and a high of 110 students during the 2018/2019 school year. In addition to providing education services for children in Anaktuvuk Pass, the school district provides several student services including bus service, sports programs, and academic and extracurricular clubs and activities. The school district also operates an early childhood education program for 3 and 4-year old children, Inupiaq classes, and a culture camp each fall. Ilisagvik College maintains a satellite computer station at the NSB Village Coordinator’s Office that offers a variety of online courses for community residents (WHPacific et al. 2016; DCCED 2020a).

2. Nuiqsut

The community of Nuiqsut is located about 35 miles from the Beaufort Sea coast on the Niglick Channel of the Colville River (DCCED 2020c). In 1973, 27 families traveled over 130 miles from Utqiagvik to the Colville River delta to permanently resettle the Kuukpikmuit ancestral homeland. The community was named Nuiqsut, for earlier camps and settlements on the main channel of the river. The return to Nuiqsut in 1973 was motivated by a desire to revive traditional Inupiat values of hunting and fishing, and experience Inupiat social and cultural life. In 1974, the ASRC funded construction of the modern village, and the City of Nuiqsut was incorporated in 1975 (NSB 2016).

Nuiqsut is undergoing social and economic change due to its proximity to oil and gas development. The Alpine oilfield is located 8 miles from Nuiqsut and partially located on lands owned by the Kuukpik Native Corporation and the ASRC. In 2018, the estimated population for Nuiqsut was 481, and 87 percent of the population was Alaska Native, Inupiat (NSB 2016; DCCED 2020c). From 2012 to 2016, the estimated annual median household income was $84,464; and, median family income was $74,750, with 5 percent of Nuiqsut’s population below the poverty level. The local economy is subsistence-based; local government employed 62 percent, and the private sector employed 38 percent of the 2016 workforce (DCCED 2020c).

Air travel provides the only year-round access. Several airlines provide commercial, passenger, freight, and mail service to the community. There are two gravel airstrips and two heliports near Nuiqsut. The Nuiqsut Airport is owned and operated by the NSB. ConocoPhillips Alaska, Inc. owns the CD-3 Airstrip that transports company employees, contractors, and cargo. A 60-mile ice road connects Nuiqsut approximately 5 to 7 months per year to Deadhorse and Prudhoe Bay, which are connected to the Alaska road system via the Dalton Highway. Trails connect Nuiqsut to Anaktuvuk Pass (140 miles) and Atqasuk (150 miles), and snowmachines and all-terrain vehicles are commonly used for local transportation (DCCED 2020c).

The NSB school district operates the Trapper School, which provides education from early childhood through grade 12, and a 2018/2019 enrollment of 174 students. The school district also provides bus service for students, an early childhood education program, Inupiaq classes, and a fall culture camp (NSB 2016; DCCED 2020c).
3. Prudhoe Bay

Prudhoe Bay is an unincorporated census designated place, which includes Deadhorse, located in the NSB, which primarily serves as a work camp for the oil industry. All residents are employees of oil industry and support services. Living quarters and food are provided to the workforce, and there are several recreational facilities (DCCED 2020d).

Before 2010, employees at remote work sites throughout the NSB were not counted in census surveys, which explains the significant increase in population estimates from 5 residents in 2000 to 2,174 residents in 2010. The population estimate of 2,174 residents, based on the 2010 census, has remained the same between 2010 and 2018 (DOLWD 2018b). About 84 percent of Prudhoe Bay’s population is white and 7 percent is Alaska Native or American Indian (DCCED 2020d).

Prudhoe Bay is accessible year-round by both road and air travel, but air travel is the primary means of public transportation to the North Slope. The state-owned and operated Deadhorse Airport is served by a variety of aircraft and can accommodate Boeing 737 jet aircraft. The Deadhorse Airport is used primarily for commercial air and cargo service. The state also owns a heliport located at Prudhoe Bay/Deadhorse. The Dalton Highway is used year-round to haul cargo to the North Slope. There are no services beyond Prudhoe Bay and the highway is hazardous during winter months (DCCED 2020d).

4. Utqiaġvik

Utqiaġvik is the economic, transportation, and administrative center for the NSB. Utqiaġvik is located 10 miles south of Point Barrow on the Chukchi Sea coast. The area encompasses 18 square miles of land and 3 square miles of water (NSB 2015). Utqiaġvik was incorporated in 1958 as a first-class city with a seven-member council elected by the city voters (NSB 2015). Six council members are elected to specific seats and the Mayor is elected at large (NSB 2015).

In 2018, the estimated population for Utqiaġvik was 5,256 (DCCED 2020e). Approximately 61 percent of the population is Alaska Native or American Indian. From 2012 to 2016, the estimated median household income was $78,804, and median family income was $94,107. About 11 percent of Utqiaġvik’s population was estimated to be below the poverty level (DCCED 2020e). Local government employed 57 percent of the 2016 workforce, state government employed 1 percent, and 15 percent was employed in education and health services (DOLWD 2016b).

Year-round access is provided by air travel. The state owns and operates the Wiley Post-Will Rogers Memorial Airport, and it serves as the regional transportation center for the NSB. The airport has controlled airspace and a 7,100-foot-long asphalt runway that can accommodate larger commercial airplanes such as Boeing 737 (AirNav 2018). Marine and land transportation provide seasonal access (DCCED 2020e).

The NSB school district operates four schools in Utqiaġvik. The Fred Ipalook Elementary School provides education from pre-kindergarten through fifth grade. The Eben Hopson Middle School provides education for students in grades six through eight. The Utqiaġvik High School provides education for students in grades 9 through 12. The Kiita Community Learning Program is an alternative high school. Utqiaġvik also has a community college, Ilisaġvik College, which is the only federally-recognized tribal college in Alaska. It offers higher education opportunities including Associates degrees and vocational training for Utqiaġvik and North Slope residents (Ilisaġvik 2018). The common goal for all educational programs, especially at high school and college levels, is to prepare students to participate in the job market, tailoring many programs to meet the needs of employers of the North Slope (NSB 2015).
E. Climate

Alaska’s North Slope is characterized by long, cold, dark winters and short, cool summers with near constant daylight. Temperatures typically remain below freezing from mid-October into May (URS Corporation 2005). Climate in the Sale Area is influenced by both the Arctic Ocean to the north and the Brooks Range mountains to the south that affect variation in precipitation and air temperature from the coastal plain, to the foothills (most of the Sale Area), to the Brooks Range. Annual precipitation along the coast averages 4 to 5 inches per year with about 75 percent of precipitation occurring during June to October (WRCC 2018). Streams and lakes remain frozen for much of the year and snow typically covers the tundra from October through May. Surface winds along the southern Beaufort Sea coast average 10 to 14 miles per hour (Wendler et al. 2010), with occasional intense storms generating winds more than 70 miles per hour. Winds are predominately from the northeast, although the strongest winds come from the west. September and October are the windiest months on the coast, which coincide with the maximum amounts of open water (Wendler et al. 2010). The 3-month ice-free season is critical to biological productivity for the region.

The onset of snowmelt and subsequent runoff often begins earlier in the foothills than in the rest of the area and moves north as the summer season progresses. Freeze-up usually begins first on the coastal plain and proceeds southward. Winters are severe, forcing many species to migrate south. The North Slope climate is strongly influenced by the continental and marine environments, with the marine influence strongest on the coast and in the summer and diminishing gradually inland. Precipitation also varies east to west, with lands to the east tending to be wetter (Searby and Hunter 1971; Wendler et al. 2010).

1. Temperature and Precipitation

On the coastal plain, temperatures fall below freezing between October and May. February is the coldest month with an average temperature of minus 17°F, and July is the warmest month with an average temperature of 53°F. Extreme temperatures can range from minus 56°F to 78°F. In the Brooks Range and foothills areas, the average January temperature is warmer at minus 21°F, and the average summer temperature is cooler at about 55°F (Zhang et al. 1997; URS Corporation 2005; Wendler et al. 2014).

The climate in the Sale Area is more continental, in that the winters are cold and the summers are warm. Monthly mean air temperatures fall below freezing during the cold season from October through April with seasonal transitions in September and May. Summer temperatures are the warmest in the lower foothills, cooler in the middle foothills, and coldest in the upper foothills (Figure 3.4 and Figure 3.5). During the cold season, the lower foothills is the coldest, followed by the middle foothills, and the upper foothills are warmest. The amplitude (Figure 3.5) of the average temperature plot is greater for the lower foothills, followed by the middle foothills, with the upper foothills having the lowest amplitude (primarily because of effect of altitude on decreasing summer temperatures). The upper foothills are at the optimum location (both elevation and latitude) for having the highest annual air temperature. Most of the warmest temperatures occur in June while the coldest temperatures occur in January (Kane et al. 2014).
Figure 3.4.—Meteorological stations and mean annual precipitation in the Sale Area.
Figure 3.5.—Monthly mean air temperatures (°F) in the lower, middle and upper Sale Area.

Source: (adapted from; Kane et al. 2014)
Precipitation in the foothills falls as about 1/3 snow and 2/3 rain. Warm season rainfall in the Sale Area exhibits a strong north-south gradient with more rainfall at higher elevations in the Brooks Range, such that the foothills receive about twice and the mountains receive about three times as much rainfall as the coastal plain. Snow depth and snow water equivalents are more uniformly distributed across the Sale Area with the end-of-winter snow depth averaging 17.4 inches (443 millimeters) from 2008 to 2017 across the Upper Kuparuk and Innnavait drainages (Stuefer, Kane, Gieck, et al. 2019; Stuefer, Kane and Dean 2019). Annual precipitation (rain and snow) then ranges from about 13.4 inches (340 millimeters) at the south boundary to about 8.7 inches (220 millimeters) at the north Sale Area boundary (Figure 3.4). The predominant wind directions in the lower foothills at White Hills are west-southwest and east-northeast, like the prevailing wind directions on the coastal plain at Northwest Kuparuk. Generally low-pressure systems generate precipitation and winds from the west-southwest, while high-pressure systems generate clear skies and winds form the east-northeast (Kane et al. 2014).

Tables 3.2 and 3.3 show the long-term mean temperature and precipitation for the arctic coastal plain at Kuparuk and the Brooks Range foothills at Toolik Lake from north to south across the Sale Area (WRCC 2018; EDC 2020).

### Table 3.2.—Temperature (°F) and precipitation (inch) normal means for Kuparuk 1981–2010.

<table>
<thead>
<tr>
<th>Normal</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum temperature</td>
<td>-20.8</td>
<td>-21.7</td>
<td>-19.8</td>
<td>-4.3</td>
<td>18.9</td>
<td>35.1</td>
<td>41.0</td>
<td>39.1</td>
<td>31.1</td>
<td>12.3</td>
<td>-7.4</td>
<td>-15.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Mean temperature</td>
<td>-15.4</td>
<td>-16.1</td>
<td>-13.6</td>
<td>2.5</td>
<td>23.7</td>
<td>41.4</td>
<td>48.8</td>
<td>45.1</td>
<td>35.4</td>
<td>16.7</td>
<td>-1.8</td>
<td>-10.0</td>
<td>13.2</td>
</tr>
<tr>
<td>Maximum temperature</td>
<td>-10.0</td>
<td>-10.5</td>
<td>-7.4</td>
<td>9.3</td>
<td>28.6</td>
<td>47.7</td>
<td>56.6</td>
<td>51.0</td>
<td>39.7</td>
<td>21.2</td>
<td>3.8</td>
<td>-4.4</td>
<td>18.9</td>
</tr>
<tr>
<td>Mean precipitation</td>
<td>0.12</td>
<td>0.09</td>
<td>0.08</td>
<td>0.16</td>
<td>0.07</td>
<td>0.32</td>
<td>0.89</td>
<td>1.04</td>
<td>0.44</td>
<td>0.30</td>
<td>0.15</td>
<td>0.14</td>
<td>3.80</td>
</tr>
</tbody>
</table>

Source: Kuparuk Station – Western Region Climate Center 2018

### Table 3.3.—Temperature (°F) and precipitation (inch) means for Toolik Lake 1989–2019.

<table>
<thead>
<tr>
<th>Normal</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum temperature</td>
<td>-43.4</td>
<td>-39.4</td>
<td>-37.0</td>
<td>-23.9</td>
<td>-2.9</td>
<td>25.2</td>
<td>31.8</td>
<td>23.5</td>
<td>5.1</td>
<td>-16.4</td>
<td>-31.1</td>
<td>-38.6</td>
<td>-11.4</td>
</tr>
<tr>
<td>Mean temperature</td>
<td>-8.5</td>
<td>-4.4</td>
<td>-3.9</td>
<td>10.4</td>
<td>29.9</td>
<td>47.5</td>
<td>52.4</td>
<td>45.0</td>
<td>31.8</td>
<td>13.3</td>
<td>-0.1</td>
<td>-7.2</td>
<td>17.9</td>
</tr>
<tr>
<td>Maximum temperature</td>
<td>29.8</td>
<td>30.2</td>
<td>29.4</td>
<td>41.9</td>
<td>58.2</td>
<td>71.3</td>
<td>73.1</td>
<td>67.9</td>
<td>57.2</td>
<td>39.4</td>
<td>29.2</td>
<td>30.1</td>
<td>47.0</td>
</tr>
<tr>
<td>Mean precipitation</td>
<td>0.32</td>
<td>0.41</td>
<td>0.31</td>
<td>0.28</td>
<td>0.69</td>
<td>1.68</td>
<td>3.26</td>
<td>2.54</td>
<td>1.29</td>
<td>0.64</td>
<td>0.46</td>
<td>0.40</td>
<td>11.01</td>
</tr>
</tbody>
</table>

Source: (EDC 2020)

### 2. Climate Change

The average global temperature, an average over the entire surface of the planet, has increased by about 2°F since 1880 increasing at a rate of about 0.27°F to 0.36°F per decade, with 2/3 of the warming occurring since 1975 (Carlowicz 2020). Global temperature depends on the amount of energy received from the sun and the amount of energy radiated back into space. The amount of energy radiated by the earth depends on the chemical composition of the atmosphere, particularly
the amount of heat-trapping greenhouse gases. Unlike global temperature, local or regional temperatures fluctuate substantially due to predictable cyclical events, like night and day, summer and winter, and variable, sometimes hard-to-predict, wind and precipitation patterns (Carlowicz 2020).

Temperatures are increasing in Alaska more rapidly than in other parts of the United States, making Alaska a forefront for climate change. The mean annual temperature change in Alaska from 1949 to 2018 follows an increasing linear trend of 4.0°F, and 2.8°F from 1976 to 2018. Seasonal mean temperature increases were greatest in winter and spring from 1949 to 2018, and in fall from 1976 to 2018. Mean annual temperatures for 2019 at Utqiaġvik was 9.1°F above 1981 to 2010 normal temperatures (ACRC 2019). These changes in seasonal temperatures have resulted in earlier spring snowmelt and later snow accumulation in the fall on the North Slope (Cox et al. 2017).

Precipitation has also increased throughout the state over the past 50 years with the annual trend from 1969 to 2018 in the Sale Area an increase of 9.5 percent (Thoman and Walsh 2019). The Arctic was wetter than normal in 2019, with above average monthly precipitation from February through November and an annual average that was 223 percent above the 1981 to 2010 normal (ACRC 2019).

Effects of climate warming of most concern for the Sale Area include: thermokarst from permafrost warming, flooding and erosion from increasing precipitation and runoff, and shortened tundra travel from shrinking snow cover seasons. The physical changes from arctic warming including increased offshore open water, increased snow-free season, permafrost warming, and increased precipitation are interrelated processes (Bintanja and Selten 2014; Cox et al. 2017; Markon et al. 2018).

During the last quarter of the 20th century, permafrost temperatures warmed across northern Alaska from Utqiaġvik to the Alaska-Canada border coincident with a statewide increase in air temperatures that began in 1977 (Jorgenson et al. 2010; Wendler et al. 2014). From Prudhoe Bay, warming extended south through the Brooks Range. The magnitude of warming at the surface of the permafrost (through 2003) averaged 5°F west of the Colville River, ranged from 5 to 7°F for the Beaufort Coastal Plain at Prudhoe Bay, and somewhat less at Utqiaġvik and Barter Island and to the south (Jorgenson 2011). Warming air temperatures were seasonal, with the largest increases during winter (October through May), and smallest changes during summer (June through September). Snow covers were thicker than normal during the late 1980s and the 1990s, which contributed to permafrost warming (Jorgenson 2011). Permafrost temperatures at depths of 30 to 65 feet have also warmed by 2 to 5°F from the 1980s to 2018 at sites along the Dalton Highway (Thoman and Walsh 2019).

Climate warming is projected to increase precipitation, evapotranspiration, and permafrost degradation which contribute to observed changes in annual streamflow intensifying hydrologic cycles for North Slope rivers. Enhanced local evaporation from the Arctic Ocean resulting from increased open water due to reduced sea ice extent leads to increased precipitation in coastal areas that is likely to increase runoff and freshwater input to nearshore waters (Bintanja and Selten 2014). Snow surveys from Innavaït Creek and the Upper Kuparuk River watersheds have increasing trends in average end-of-winter snow water equivalent (Stuefer et al. 2020). Increased runoff has been measured for the Putuligayuk and Kuparuk river watersheds. The Putuligayuk River, located entirely on the coastal plain, has shown an increase in runoff by 25.5 to 40.5 percent between 1970 to 1986 and 1999 to 2015, with increased annual variability in recent decades. While, mean annual runoff for the Kuparuk River, originating in the Brooks Range and crossing through the Sale Area has increased more gradually by 9.2 to 14.7 percent between 1970 to 1986 and 1999 to 2015 (Stuefer et al. 2017).

Earlier snowmelt and delayed snow cover have lengthened the snow-free season by an estimated 6.6 days per decade between 1975 and 2016 near Utqiaġvik. This increase in the length of the
snow-free season changes the amount of solar radiation absorbed at the surface and propagated through the subsurface affecting soil temperature and propagated through the atmosphere affecting air temperature and stability (Cox et al. 2017). Shortened snow-cover and frozen ground conditions reduce the window for overland travel by snowmachine or dogsleds for subsistence and for building snow and ice roads for exploration activities. Drivers for the changing snow-cover cycles on the North Slope are primarily related to large-scale exchange of air mass and energy from lower latitudes during spring and regional sea ice conditions during fall (Cox et al. 2017).

F. Natural Hazards

Natural hazards are processes or phenomena that may cause loss of life, injury or health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (Holmes et al. 2013). Natural hazards potentially impacting oil and gas activities and infrastructure within the Sale Area include: faults and earthquakes; permafrost thawing and subsidence; mass movements; flooding, erosion, and ice jams (Craig et al. 1985; Hubbard 2008); overpressured sediments; and shallow gas deposits and natural gas hydrates. Much of the foothills, including the Sale Area, is in an area of potential overpressures in the shallow subsurface (depths from a few hundred feet to a few thousand feet), and within the methane hydrates stability zone as mapped by the US Geological Survey (2013). Although overpressures, shallow free gas, and methane hydrates are not likely continuous throughout the area, there is the potential for these hazards to be present locally.

Changes in climate can alter natural processes that can increase the magnitude and frequency of natural hazards such as permafrost thawing; slope instability; river flooding, erosion and ice jams; avalanches (Wolken et al. 2017); and wildland fires. If potential natural hazards are not properly identified and addressed through siting and engineering, they can have damaging effects on Alaska’s communities and infrastructure (Wolken et al. 2017). Natural hazards could constrain oil and gas exploration, development, production, and transportation and must be considered in the siting, design, construction, and operation of facilities.

When assessing potential impacts from geologic hazards understanding of the types of geologic materials and processes, their properties and distribution is crucial. Long, linear ridges, buttes, and mesas of tightly folded sedimentary rocks divide narrow alluvial valleys and glacial moraines. Above a thick, continuous layer of permafrost are ice-related features, such as gelifluction lobes, pingos, and ice-wedge polygon networks. Because permafrost impedes drainage, soils are usually saturated and have thick organic horizons.

Most surficial geologic mapping in the region has been done at a reconnaissance level and more detailed work should be completed prior to siting design and infrastructure development. Reconnaissance mapping of the Philip Smith Mountains (Hamilton 1978), Chandler Lake (Hamilton 1979), and Killik River (Hamilton 1980) quadrangles was completed at a scale of 1:250,000 and engineering-geologic maps have been published for the Ipiikpuk River (Carter and Galloway 1988), Umiat (Carter and Galloway 1986), and Sagavanirktok quadrangles (Hubbard 2016). Other maps have been published documenting surface geologic materials and hazards along potential transportation corridors within the Sale Area (Stevens and Smith 2003; Stevens, Bowman, et al. 2003a, b, c, d).

Bedrock outcrops are more common at higher elevations and close to the Brooks Range, although exposures along streams and steeper slopes is not uncommon. Valley bottoms, slopes and low hills in the Sale Area are typically covered by unconsolidated deposits including: alluvium, outwash, glacial drift, colluvium, ice-rich upland silt, and low-lying silt and sand deposits. Alluvium and outwash are found along stream bottoms and former glacial drainage channels and include terrace and floodplain materials. These deposits typically range from poorly sorted to moderately well
stratified subangular coarse gravel with cobbles and boulders near moraine fronts and at the heads of mountain valleys to well-sorted sandy gravel with sub-rounded pebbles and cobbles along some stream stretches (Hamilton 1978, 1980).

Glacial drift consists of poorly sorted nonstratified material, ranging in composition from silty sandy boulder gravel to clayey stony silt, with local stratified ice-contact deposits consisting of moderately well sorted sand and gravel (Hamilton 1978, 1980). These deposits are associated with Tertiary, Pleistocene and Holocene glacial advances northward from the Brooks Range and may form arcuate landforms (moraines) adjacent to stream valleys. Thin glacial drift locally mantles upland areas, especially in the northern foothills of the Brooks Range. Younger deposits tend to retain primary glacial morphology while older deposits have less relief and are more heavily modified by slope processes.

Colluvial deposits associated with downslope movement of material are common throughout the Sale Area along and at the base of many slopes, and range from angular rock debris to poorly sorted, nonstratified mixtures of sand, silt and clay (Hamilton 1980). Colluvial deposits may pose significant geologic hazards due to their potential instability. Deposits in the low-lying areas beyond the limits of glaciation in the northern part of the Sale Area generally consist of silt and sand, commonly in the form of loess and dunes. Loess deposits typically contain abundant ice in the form of lenses, wedges and interstitial grains (Hamilton 1980). Such deposits may be organic rich and are especially subject to hazards associated with permafrost. These deposits commonly display evidence of solifluction and slope movement on steeper surfaces (Hamilton 1980).

1. Faults and Earthquakes

The Sale Area is situated adjacent to the transition between two major geologic structures—the Colville Basin and the Barrow Arch. Formation of the Colville Basin, Barrow Arch, and the associated Brooks Range was initiated during mid-Cretaceous compression of the Arctic Alaska plate, produced by rift-zone expansion in the marine basin bordering the plate to the north. The resulting deformation formed the Brooks Range thrust-fault belt and the foreland Colville Basin and Barrow Arch (Moore et al. 1994). Present-day seismic activity and deformation of Quaternary sediments result from the continuation of mountain building in the Brooks Range. Surface faults have been mapped throughout the central North Slope, including high-angle faults, basement-involved normal faults, listric growth faults, and north-dipping gravity faults (Koehler et al. 2012).

High-angle faults are located along the Barrow Arch extending into Harrison Bay. Along the Barrow Arch, these faults are related to the basement tectonics of the Arctic Platform, while in Harrison Bay they offset Tertiary and older units. Displacement of Pleistocene or Holocene sediments has not been documented and there has been no recent seismicity associated with these faults. Thus, differential movement along these faults seems to have ended prior to the beginning of the Quaternary period (Craig and Thrasher 1982). Within the Sale Area, several east-west trending structures have been mapped along the north side of the Brooks Range (Figure 3.6). These structures offset Paleogene bedrock (older than about 24 million years) and are not known to have been active in the Quaternary (Plafker et al. 1994).

North of the Sale Area on the outer Beaufort shelf and upper slope, at depths of 2,000 to 2,600 feet, are gravity faults related to large rotational slump blocks (Craig et al. 1985). South of these slumps, which bound the seaward edge of the Beaufort Ramp, these faults have surface offsets ranging from 50 feet to more than 225 feet. Studies infer that these faults were active in recent geologic time based on the age of the faults, and therefore pose a hazard to bottom-founded structures in this area. Large-scale gravity slumping of the blocks here could be triggered by shallow-focus earthquakes centered in Camden Bay or in the Brooks Range (Craig et al. 1985).
The arctic coastal plain north of the Brooks Range generally experiences little seismic activity, except for an area of the northeast Brooks Range east of the Canning Zone into Camden Bay (Page et al. 1991; Koehler et al. 2018). Potential earthquake sources include the Marsh Creek anticline, Camden anticline, Camden Bay faults (Figure 3.6), and potentially other poorly-documented faults (Koehler et al. 2018). Although seismic rates are low and surface evidence of tectonic events is subtle, the structures on the arctic coastal plain may be capable of moderate earthquakes (Koehler et al. 2018). Most earthquakes of 2.5 magnitude or greater between 1960 and 2019 within 50 miles of the Sale Area were shallow—96 percent of earthquakes were less than 20 miles deep—indicating near-surface faulting (Koehler et al. 2018; USGS 2020a).

Three recent epicenters occur in the northeastern corner of the Sale Area (Figure 3.6); a 5.2 magnitude earthquake at 35 miles deep on August 31, 1995, a 2.8 magnitude earthquake at 13 miles deep on March 15, 2008, and a 2.8 magnitude at 35 miles deep on July 3, 2019 (USGS 2020a). The largest earthquake recorded north of the Brooks Range at magnitude 6.4, and the fourth largest in Alaska in 2018, occurred on the morning of August 12, 2018, 52 miles southwest of Kaktovik (M6.4 Kaktovik). M6.4 Kaktovik triggered a series of aftershocks including the second largest earthquake north of the Brooks Range, at 6.0 magnitude. M6.4 Kaktovik ruptured an easterly trending strike-slip fault and generated over 4,000 aftershocks (Dickson et al. 2019). This earthquake and aftershock were 16-miles deep and located about 23 and 43 miles northeast from the eastern edge of the Sale Area, respectively (Figure 3.6).

Wesson and others (2007) estimate a 10 percent probability of exceeding 0.07 g\(^3\) earthquake-generated peak ground acceleration in bedrock during a 50-year period near the Sale Area. For comparison, peak ground acceleration in Anchorage during the 1964 Great Alaska Earthquake was estimated at 0.15 to 0.20 g (Stark and Contreras 1998). Ground accelerations are likely to be higher in parts of the Sale Area that are underlain by thick, soft sediments, than in bedrock due to amplification. Thick localized permafrost may cause frozen sediments to behave more like bedrock during an earthquake, which could limit amplification effects and prevent earthquake-induced ground failure, such as liquefaction (Hubbard 2008).

\(^3\) Gravitational acceleration. One g equals an acceleration rate of 32 feet per second.
Chapter Three: Sale Area Description

Source: (Plafker et al. 1994; USGS 2020a, b)

Figure 3.6.—Earthquakes and faults in and around the Sale Area 1960 to 2019.
2. Permafrost

Permafrost is defined as ground (soil and rock as well as included ice and organic matter) that remains at or below 32°F for at least two consecutive years and can be found in both unconsolidated sediment and in bedrock. The mean annual temperature of permafrost in its stable thermal state is lowest at the permafrost table and increases with depth in accordance with the geothermal gradient. Seasonal freezing in the permafrost region is often along two fronts, occurring both downwards from the surface and upwards from the underlying perennally-frozen material (French and Shur 2010). Permafrost underlies most land surfaces in the Arctic, including the Sale Area, and varies from a few feet to several hundred feet thick, depending on its thermal history (Frederick et al. 2016). Permafrost in the Sale Area is continuous, occupying 90 to 100 percent of the land area; unfrozen areas are generally present only beneath rivers or lakes (Martin et al. 2009). Along the Beaufort Sea on the coastal plain, permafrost extends as much as 2,000 feet below the surface and most permafrost temperatures at the depth of zero annual amplitude vary between 14 to 23°F (Kanevskiy et al. 2013).

Modern permafrost is either in equilibrium with current climate or aggrading or degrading under prevailing climate conditions. Permafrost may also be relict, or ancient, having formed under conditions that no longer exist and which is now preserved under present environmental conditions (Kanevskiy et al. 2016). Most of the permafrost in the Sale Area formed tens of thousands of years ago during the late Pleistocene, when the mean annual air temperature was much colder than present day. Permafrost in the Sale Area is continually adjusting to changes in the thermal regime (Jorgenson 2011; Frederick et al. 2016).

The vulnerability and resilience of permafrost to climate warming is complicated by dynamically changing surface properties related to snow, vegetation, active layer thickness, surface water, groundwater, and soils. Permafrost is commonly overlain by a surface layer of soil or unconsolidated sediment. The surface layer, called the active layer, typically thaws and re-freezes each year. Thawing of ice-rich permafrost causes particularly strong feedbacks to ground surface stability, microtopography, hydrology, ecosystem function, and the carbon cycle. These dynamics can allow permafrost to persist at mean annual air temperatures (MAATs) as high as 36°F along the southern margin of the permafrost and to degrade at MAATs as low as minus 4°F in the high Arctic (Jorgenson et al. 2010; Smith et al. 2010). Vegetation succession can reduce mean annual soil temperatures by as much as 43°F, while surface water can raise temperatures at the water-sediment interface by as much as 50°F (Jorgenson et al. 2010; Pastick et al. 2015).

The active layer is critical to the ecology and hydrology of permafrost terrain, as it provides a rooting zone for plants and acts as a seasonal aquifer for near-surface groundwater (Panda et al. 2016). The thickness of the active layer varies from year to year and from locality to locality, depending on controls such as ambient air temperature, slope orientation and angle, vegetation, drainage, snow cover, soil and/or rock type, and water content. Permafrost thickness is variable and depends on the amount of solar radiation, aspect, thickness and duration of snow cover, material properties, altitude, and latitude (Pastick et al. 2015). Permafrost thickness, measured from numerous wells on the North Slope, generally thins from east to west. East of Oliktok Point, it has been measured to be more than 1,600 feet thick, whereas west of the Colville River it has been measured to be 980 to 1,300 feet thick (Osterkamp et al. 1985; Clow and Lachenbruch 1998).

Ground ice within permafrost include thin lenses of ice, layered ice, reticulated vein ice, and ice wedges as large as 6 to 13 feet long and 10 to 16 feet deep in northern Alaska (Panda et al. 2016). Ice wedges and polygonal surface features (i.e., ice-wedge polygons) are typical of permafrost landscapes and are found throughout the Sale Area. Ice wedges form during winter months when thermal contraction cracks the frozen ground, much like the surface of sunbaked, dried mud. During the warmer, wetter season, water infiltrates the cracks and refreezes. Consecutive freeze-
thaw cycles cause the ice wedges to grow and expand, forming large polygonal features often clearly seen on the surface (Kanevskiy et al. 2016).

Many geologic hazards in permafrost regions are related to changes in both the active layer and permafrost thickness due to seasonal and long-term temperature fluctuations, as well as to manmade ground disturbances and structures. Vegetation and soil disturbance triggered by fires, floods, or construction can result in rapid local degradation of permafrost by thermokarst or thermoerosion, resulting in uneven topography in the form of mounds and sink holes that may leave the surface unsuitable for many construction purposes. Melting of ground ice, including segregated ice, ice wedges, and other massive ice bodies in permafrost, results in subsidence and water impoundment. Positive feedbacks from thermokarst lakes formed during the Holocene—the past 12,000 years—accelerate subsidence and permafrost thaw, mobilize deeper permafrost-stored organic carbon, and enhance greenhouse gas emissions (Pastick et al. 2015). Predisposition for thermokarst depends on permafrost presence, ice content, physiography (lowland or upland), and presence of histels (organic soil with permafrost near the surface; BLM 2015a). Thermokarst predisposition in the Sale Area ranges from low along the southern border to high along the central northern border (Figure 3.7).

Ground settlement occurs when a heated structure is placed on ground underlain by shallow, ice-rich permafrost and proper engineering measures are not taken to adequately support the structure and prevent the structure’s heat from melting the ground ice. The degree of settlement is a function of the ground ice content, the original thickness of the active layer, the increase in the active layer as it adjusts to the surface disturbance, and the thaw strain of the underlying permafrost (Jorgenson et al. 2010; Liu et al. 2010). In general, the magnitude of settlement depends primarily on the nature and abundance of ice and the severity of the disturbance; ice content is highest in fine-grained, organic-rich deposits and lowest in coarse granular deposits and bedrock (Frederick et al. 2016). Arctic lowland areas are particularly at-risk for thaw subsidence because of the high volume of ground ice at the top of the permafrost (Jorgenson 2011). The potential for thaw settlement is least in areas of active river deposits and eolian sand, and can be greater than three feet in areas of alluvial marine deposits (Kanevskiy et al. 2016). Generally, soil strength is greater during the winter when soil water is frozen than it is during summer months when melting occurs (Jorgenson et al. 2010).

In addition to settlement, seasonal freeze-thaw processes will cause frost jacking of unheated structures placed on frost-susceptible soils unless the structures are firmly anchored into the frozen ground with pilings or supported by non-frost-susceptible fill (Combellick 1994). The depth of this layer of seasonal thaw is generally less than 3 feet below most surfaces and 6 feet beneath most active stream channels, and is dependent on site-specific hydrological and geotechnical water crossing conditions (Panda et al. 2016). Borings along the Colville River, for example, show it remains thawed year-round (Jorgenson 2011). The frost susceptibility of the ground is highest in fine-grained alluvium, colluvium, and thaw-lake and thermokarst deposits; moderate in alluvial-fan deposits and till; and lowest in coarse-grained floodplain deposits and alluvial terrace deposits. Fine-grained and/or thin-bedded bedrock is subject to frost shattering along joints and bedding, but coarse-grained and/or massive bedrock is generally not frost susceptible (Ferrians 1971; Yeend 1973b, a; Carter et al. 1986).
Figure 3.7.—Thermokarst predisposition and stable gas hydrates in the Sale Area.
Continual monitoring of permafrost stability, including water content and temperature variability of soils, and continued assessment of mitigation techniques are necessary. Frozen ground problems can be successfully mitigated through proper siting, design, and construction. Structures such as drill rigs and permanent processing facilities should be insulated to prevent heat loss into the substrate. Pipelines can be trenched, back-filled, and chilled (if buried) or elevated to prevent undesirable thawing of permafrost (Hubbard 2008). In addition, the Alaska Department of Natural Resources regulates winter travel across the tundra and authorizes travel only after determining that the tundra is sufficiently frozen and protected by ample snow cover so that the travel will not have major environmental effects such as permafrost degradation (Bader and Guimond 2006).

3. Mass Movement

Mass movement is the downward and outward movement of slope-forming material under the influence of gravity (Goudie 2004). Melting ice and permafrost can facilitate movement due to the lubricating effect of water and reduction of effective stress in saturated materials. Mass-movement processes present a significant geologic hazard in the study area because they can lead to slope instability, which can impact infrastructure and development (Carter and Galloway 1986; Stevens and Smith 2003; Stevens, Reger, et al. 2003a, b, c, d; Stevens, Bowman, et al. 2003).

In the Sale Area, mass-movement processes commonly produce solifluction deposits, slides, flows, slumps, talus and rockfalls (Hamilton 1978, 1979, 1980; Nelson et al. 2001; ACIA 2004; Hobson 2006). Geologic hazards associated with mass movement are not restricted to unconsolidated materials. Depending on temperature, and material properties such as porosity, permeability and the presence or absence of discontinuities, ice can occur in bedrock (French 2007) and may influence its stability (Noetzli and Gruber 2009). Repeated expansion and contraction of ice can potentially enlarge discontinuities, leading to failure. Melting ice can also lead to mass movement by lubricating surfaces along discontinuities. Mass movement associated with bedrock failures is especially important in portions of the lease sale area where steep bedrock slopes exist (Hamilton 1978, 1979, 1980).

Mass movement of snow can also be a potential hazard in the Sale Area. Avalanches, which involve the downhill movement of snow, ice and rock debris, are possible, especially where snow accumulates on oversteepened slopes (French 2007). Slushflows, which are flowing, water-saturated snow masses, may develop on steep slopes if water content of snow increases (Tomasson and Hestnes 2000). Conditions are often favorable for slushflows during rapid snowmelt or after large rain events when snow cover is abundant (Tomasson and Hestnes 2000). Both avalanches and slushflows have the potential to cause significant damage and destruction.

In addition to hazards associated with slope movement itself, increased erosion can occur as material is delivered to streams from mass movement processes (Hobson 2006).

4. River Flooding, Bank Erosion, and Icing

The spring breakup cycle is the result of several factors including snow melt, sustained cold or warm temperatures, ice thickness, wind speed and direction, precipitation, and solar radiation. When spring flow begins, water runs over the snow and ice in river and stream channels. Floodwaters can extend considerable distances beyond channels (over bankfull). Generally, flooding subsides as channel ice is lifted from the river bottom and carried downstream, although, ice jams increase the height of floodwaters and can cause catastrophic flooding. Some of the most damaging floods on the Colville River are associated with an above-average snowpack that is melted by rainstorms and sudden warming (Walker and Hudson 2003).
Snowmelt runoff in late May/early June is the most significant hydrological event of the year in the Sale Area, although rain and mixed rain and snow events in July and August may produce floods of record in small watersheds. Ice jams are a major concern, especially in the larger river systems. Floods of record for large watersheds (Sagavanirktok, Colville, Kuparuk) in the Sale Area are primarily snowmelt-generated, while floods of record for smaller watersheds (Upper Kuparuk, Upper Itkillik, and Atigun) have a high probability of being rainfall-generated. For large watersheds, low-pressure systems that generate precipitation usually cover only a portion of the watershed, while rainfall may entirely cover a small watershed producing high runoff volumes (Kane et al. 2014).

During peak flows, side channels and sloughs were full of water on the Anaktuvuk and Chandler Rivers, while the Upper Itkillik River flow was confined to the main channel. Ice jams have been observed on all three rivers during breakup, and generally form very quickly increasing river floodwater height by at least 3 feet within minutes. Over bankfull flooding likely occurs in most years on the Anaktuvuk and the Chandler rivers, and occasionally on the Lower Itkillik River (Kane et al. 2014).

Predevelopment planning should include hydrologic and hydraulic surveys of spring breakup and ice jams, and flood-frequency analyses. Data should be collected on water levels, ice thickness, discharge volume and velocity, and suspended and bedload sediment measurements for analysis. Also, historical flooding observations should be incorporated into a hazard risk assessment. Inactive river channels should be considered for flood potential. Containment dikes and berms may be necessary to reduce the risk of flood waters that may undermine facility integrity.

Two main drivers of riverbank erosion in areas of ice-rich permafrost are thermal erosion and thermal denudation. Thermal erosion is a process of combined thermal and mechanical action that occurs when running water comes in contact with ice-cemented sediments; heat transfer at or below the river water surface causes the frozen soil to thaw quickly and be removed, creating a niche or crevice at water level (Kanevskiy et al. 2016). Removal of thawed deposits by water constantly exposes the niche of the bluff to additional thawing and growth, and results in large falling blocks of frozen ground that ultimately disintegrate in water or on banks (Kanevskiy et al. 2016). Thermal erosion of riverbanks occurs during lower river stages and flooding later in the season. Peat-rich soils tend to erode more slowly (2.5 feet/year) than mineral soils (6.5 feet/year), likely due to the fibrous mat and slower thawing of the peat (Jorgenson 2011).

Thermal denudation in areas of ice-rich permafrost involves thawing of exposed frozen soil on the surface of a bluff through solar radiation and convective heat exchange between the cold surface and the air, and the flow of water and sediment sloughing off the bluff. Thermal denudation acts on a bluff face exposed by thermal erosion and continues for years and even decades after the termination of thermal erosion. Thermal denudation during active thermal erosion can reduce the total rate of erosion because it reduces the size of blocks of frozen soil above niches, and as a result, decreases stresses in frozen ground and ice above niches, delaying block-fall events (Kanevskiy et al. 2016).

Warmer temperatures and extended open water seasons influence riverbank erosion rates and stability and must be considered in determining facility siting, design, construction, and operations; and for routing oil and gas access roads and export pipelines. Structural failure can be avoided by using setbacks and siting facilities away from actively eroding riverbanks. Road or pipeline crossings can be fortified with concrete armor, and by placing retainer blocks and concrete-filled bags in areas subject to high erosion rates.

In addition to seasonal flooding, many rivers in the Sale Area are subject to seasonal icing or aufeis formation. Aufeis grows during warm spells during the winter when pressures build up under the ice deforms and induces cracks in the ice cover that allow water to flow onto the surface and freeze.
(Kane et al. 2013). Aufeis forms where frozen or impermeable stream bed sections force winter flow to the surface or where spring-fed tributaries overflow wide braided rivers (Veldman and Ferrell 2002). In areas of repeated overflow, residual ice sheets often become thick enough to extend beyond the flood-plain margin. These large overflows and residual ice sheets have been documented on many of the streams in the study area (Dean 1984; Combellick 1994; Stevens and Smith 2003; Stevens, Bowman, et al. 2003; Stevens, Reger, et al. 2003a, b, c, d). Aufeis is an important water storage component in the Arctic, accounting for about 27 to 30 percent of the Kuparuk River groundwater discharge. Aufeis continues accumulating throughout the winter, reaching a peak in late April/early May which is released as meltwater during June and July (Yoshikawa et al. 2007).

The distribution of the aufeis is related to the distribution of limestone outcrops, proximity of mountainous terrain with adjacent terminal moraines, and faulting. Many high-discharge Brooks Range springs are located about 2,000 feet above sea level, with most all springs occurring between 650 and 3,000 foot elevations (Yoshikawa et al. 2007). Aufeis forming springs are concentrated in the eastern Brooks Range primarily east of the Dalton Highway along the southeastern border of the Sale Area (Yoshikawa et al. 2007) where groundwater recharged on the south side of the Brooks Range is discharged through taliks in the permafrost where faults are present (Kane et al. 2013). While the formation and melting of aufeis from springs is sensitive to water temperature and discharge volume, aufeis appears to be less sensitive to climatic change (Yoshikawa et al. 2007).

5. Overpressure Sediments

Along the central Beaufort Sea region, extremely high pore pressures can be expected where Cenozoic strata (sedimentary layers) are very thick, such as in the Kaktovik, Camden, and Nuwuk Basins. Onshore, in the Camden Basin, high pore pressures have been measured in both the Tertiary and Cretaceous formations where the burial depths of the Tertiary strata exceeded 2 miles (Craig et al. 1985). In the Point Thomson area, the pore pressure gradients were measured as high as 0.8 pounds per square inch per foot (psi/ft) in sediments at burial depths of 2.5 miles. In this area, a pore pressure gradient of 0.433 psi/ft is considered normal (Craig et al. 1985). Although overpressure sediments are not likely continuous throughout the Sale Area, there is the potential for this hazard to be present locally.

Drilling mud in the well-bore is mixed to a specific density that will equal or slightly exceed the pressure in the formation. When formation pressures exceed the weight of the drill mud in the well-bore, the result can be a kick

\[4 \text{ A kick is a condition where the formation fluid pressure (pressure exerted by fluids in a formation) exceeds the hydrostatic pressure (pressure exerted by mud in the borehole) resulting in a 'kick': formation fluids enter the borehole.}\]

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Drilling mud in the well-bore is mixed to a specific density that will equal or slightly exceed the pressure in the formation. When formation pressures exceed the weight of the drill mud in the well-bore, the result can be a kick. Thus, encountering over-pressured sediments while drilling can result in a blow-out or uncontrolled flow. The risk of a blow-out is reduced by identifying locations of overpressure sediments via seismic data analysis, and then adjusting the mud mixture accordingly as the well is drilled. If a kick occurs, secondary well control methods are employed. The well is shut-in using the blow-out prevention (BOP) equipment installed on the wellhead after surface casing is set. The BOP equipment closes off and contains fluid pressures in the annulus and the drill pipe. BOP equipment is required for all wells, and surface and sub-surface safety valves are required to automatically shut off flow to the surface.

6. Shallow Gas Deposits and Natural Gas Hydrates

Both onshore and offshore boreholes have encountered shallow pockets of natural gas throughout the Arctic. This gas usually exists in association with faults that cut Brookian (Aptian through Miocene) strata, and as isolated concentrations in the Pleistocene coastal plain sediments (Grantz et

\[4 \text{ A kick is a condition where the formation fluid pressure (pressure exerted by fluids in a formation) exceeds the hydrostatic pressure (pressure exerted by mud in the borehole) resulting in a 'kick': formation fluids enter the borehole.}\]
Sediments in which gas has accumulated are a potential hazard if penetrated during drilling, as well as for any man-made structures on top of them. The presence of gas may lower the shear strength of sediments and reduce their ability to support structures (Hubbard 2008). Although shallow free gas and methane hydrates are not likely continuous throughout the Sale Area, there is the potential for these hazards to be present locally (USGS 2013).

Natural gas hydrates are unique compounds consisting of ice-like substances composed of gas trapped within water molecules (Nixon and Grozic 2007). They commonly occur offshore under low-temperature, high-pressure conditions, as well as at shallower depths associated with permafrost (Ruppel 2018). Gas hydrates have been found at shallow depths under permafrost along the inner shelf and onshore at Prudhoe Bay (Craig et al. 1985; USGS 2013).

One of the main problems associated with gas hydrates is dissociation, which occurs when the compound becomes unstable. Dissociation can be natural or man-made and leads to an increase in fluid pressure and reduction of effective stress of sediment as volume increases (Nixon and Grozic 2007). Potential for dissociation in marine environments is a function of water depth, sea floor temperature, and availability of gas and water in adequate quantities. Natural mechanisms leading to gas hydrate dissociation include sea level decrease and sediment temperature increase. Man-made mechanisms include heat transfer during petroleum production leading to melting of hydrates. During drilling, rapid decomposition of gas hydrates can cause a rapid increase in pressure in the wellbore, gasification of the drilling mud, and the possible loss of well control. If the release of the hydrate gas is too rapid, a blowout can occur, and the escaping gas could be ignited. In addition, the flow of hot hydrocarbons past a hydrate layer could result in hydrate decomposition around the wellbore and loss of strength of the affected sediments (Nixon and Grozic 2007). If this happened and the well was shut-in for a sufficient period of time, the reformation of the hydrates could induce high pressures on the casing string (Hubbard 2008).

7. Mitigation Measures

Natural hazards in the Sale Area pose potential risks to oil and gas infrastructure. Detailed site-specific studies may be necessary to identify specific earthquake, ice-rich permafrost, slopes prone to mass wasting or avalanches, and river reaches prone to ice jams, flooding, erosion, and icings. The risks from earthquake damage can be minimized by siting onshore facilities away from potentially active faults and unstable areas, and by designing facilities to meet or exceed national standards and International Building Code seismic specifications for Alaska. Site-specific shallow hazard surveys to identify overpressure sediments, shallow gas, and gas hydrates, and use of mechanisms for well control and blow-out prevention reduce risk of loss of life or damage to the environment from these hazards. For a discussion of oil spill prevention and response see Chapter Six.

Safe design of oil and gas facilities are based upon design codes and recommended practices that assist the engineer by setting out procedures for achieving acceptable levels of safety. Recommended practices provide guidance for the design of arctic structures and pipelines considering the environment and permafrost. Once the design conditions have been established for each process, they become the basis for that system’s design. The primary goal of codes is safety, which is accomplished by providing a minimum set of rules that must be incorporated into a sound engineering design for materials, fabrication, testing, and examination practices used in the construction of these systems. All of these are intended to achieve a set of engineering requirements deemed necessary for safe design and construction of these structures and their associated piping systems. Industry standards are constantly reviewed and upgraded by select committees of engineers and other technical experts (PHMSA 2018).
Although natural hazards could potentially damage oil and gas infrastructure, measures in this best interest finding, regulations, and design and construction standards are expected to avoid and minimize risks to infrastructure and for environmental damage. Mitigation measures in this finding address siting, design, and construction of oil and gas facilities and pipelines. A complete list of required mitigation measures is found in Chapter Nine.

G. References


Chapter Three: Sale Area Description


Chapter Three: Sale Area Description


Chapter Four: Habitat, Fish and Wildlife

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Chapter Four: Habitat, Fish and Wildlife

This chapter considers and discusses the habitats and fish and wildlife populations of the North Slope Foothills Areawide lease sales area (Sale Area), as required by AS 38.05.035(g)(1)(B)(iii). The intent is to focus on habitats and fish and wildlife of the area that have important subsistence, recreational, or commercial value and that are material to the determination of whether lease sales will best serve the interests of the state (AS 38.05.035(e)(1)(A)-(B)). Uses of fish and wildlife is discussed further in Chapter Five, and potential cumulative effects to fish and wildlife from oil and gas exploration and development is discussed in Chapter Eight.

Most (98 percent) of the Sale Area is within the Brooks Foothills ecoregion, characterized by rolling hills, continuous permafrost, braided streams and rivers, and slope-related periglacial features. In a few locations the south and east boundaries (2 percent) of the Sale Area cross into the Brooks Range ecoregion, characterized by steep mountains of sedimentary and metamorphic rock, high energy streams through steep valleys, and numerous lakes (Nowacki et al. 2001).

A. Habitats

Key wildlife habitats within the Sale Area include: arctic and alpine tundra; low and tall shrubs; wetlands; and freshwater rivers and lakes (ADF&G 2015b). Of these key habitats, tundra predominates covering 57 percent of the Sale Area, followed by low and tall shrubs at 26 percent, and freshwaters at 2 percent. While most (74 percent) of the Sale Area is mapped as uplands, emergent and scrub-shrub wetlands cover about 24 percent of the Sale Area.

1. Terrestrial Habitats

The Brooks Foothills are dominated by shrub-sedge tussock tundra with willow Salix spp. thickets along rivers and mountain-avens or Dryas tundra Dryas spp. along ridges. Tussock-forming vegetation is primarily tussock cotton-grass Eriophorum vaginatum. Shrubs may include dwarf birch Betula nana, diamond-leaf willow Salix pulchra, marsh Labrador-tea Rhododendron tomentosum, bog blueberry Vaccinium uliginosum, and low-bush cranberry Vaccinium vitis-idaea. Bare soil and bedrock support lichens and scattered herbaceous vegetation. Mesic areas, with deeper soils (e.g., depressions and saturated sites) support willow, ericaceous shrubs, mesic graminoid communities, and tussock forming sedges. Foothill valleys support a mix of shrub communities dominated by willow, dwarf birch, and alder Alnus spp. (Berkowitz et al. 2017). Terrestrial habitats in the Sale Area are dominated by tussock tundra, 51.6 percent, and dwarf and low shrubs, 28.8 percent (Table 4.1 and Figure 4.1).
Table 4.1.—Terrestrial habitats in the Sale Area.

<table>
<thead>
<tr>
<th>Land Cover Class</th>
<th>Description</th>
<th>Approximate Area (acres)</th>
<th>Area Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Ground</td>
<td>Barren river bars, scree slopes</td>
<td>34,298</td>
<td>0.5%</td>
</tr>
<tr>
<td>Sparse Vegetation</td>
<td>Common on floodplains, alpine slopes</td>
<td>85,780</td>
<td>1.2%</td>
</tr>
<tr>
<td>Herbaceous Marsh: Carex aquatilis/Arctophila fulva</td>
<td>Emergent water sedge Carex aquatilis or pendantgrass Arctophila fulva</td>
<td>53,772</td>
<td>0.7%</td>
</tr>
<tr>
<td>Herbaceous Wet Sedge</td>
<td>Wet areas with water sedge and cotton grass, bog and fen habitats</td>
<td>237,202</td>
<td>3.2%</td>
</tr>
<tr>
<td>Herbaceous Mesic Sedge-Shrub</td>
<td>Wet areas with sedge and mountain-avens Dryas spp.</td>
<td>534,399</td>
<td>7.2%</td>
</tr>
<tr>
<td>Tussock Tundra</td>
<td>Mesic to wet soils with tussock cottongrass Eriophorum vaginatum</td>
<td>806,757</td>
<td>10.9%</td>
</tr>
<tr>
<td>Tussock Shrub Tundra</td>
<td>Mesic to wet soils with tussock cottongrass and low shrubs</td>
<td>2,999,049</td>
<td>40.7%</td>
</tr>
<tr>
<td>Dwarf Shrub</td>
<td>Floodplains or alpine, mountain-avens Dryas spp. or ericaceous shrubs</td>
<td>222,889</td>
<td>3.0%</td>
</tr>
<tr>
<td>Dwarf Shrub – Lichen</td>
<td>Alpine Dryas-lichen tundra</td>
<td>209,876</td>
<td>2.8%</td>
</tr>
<tr>
<td>Low Shrub - Birch</td>
<td>Dwarf arctic birch Betula nana and ericaceous or willow shrubs, floodplain, upland</td>
<td>1,082,716</td>
<td>14.7%</td>
</tr>
<tr>
<td>Low Shrub - Willow</td>
<td>Diamond-leaf Salix pulchra or Richardson willow Salix lanata, floodplain, upland</td>
<td>609,264</td>
<td>8.3%</td>
</tr>
<tr>
<td>Tall Shrub – Alder</td>
<td>Green alder Alnus viridis, gravelly slopes and floodplains</td>
<td>255,911</td>
<td>3.5%</td>
</tr>
<tr>
<td>Spruce Forest/Woodland</td>
<td>White or black spruce</td>
<td>15</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>Burned Area</td>
<td>Primarily related to the Anaktuvuk River fire in July 2007</td>
<td>214,002</td>
<td>2.9%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7,377,674</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: (Boggs, Flagstad, Aisu, et al. 2019)
Source: (Boggs, Flagstad, Aisu, et al. 2019)

Figure 4.1.—Land cover in the Sale Area.
a. Plant Functional Type and Species Coverage

In addition to the categorical vegetation mapping presented above (Boggs, Flagstad, Aisu, et al. 2019), recent vegetation mapping for cover by tundra plant functional types (PFTs), and foliar cover on the North Slope based on modeled spectral analysis have been completed for portions of the Sale Area (Macander et al. 2017; Nawrocki et al. 2020). The tundra PFTs mapping covers 84 percent of the Sale Area (Macander et al. 2017), and foliar cover mapping covers 74 percent of the Sale Area (Nawrocki et al. 2020). Expansion of shrubs has been observed in the arctic and is of interest because shrub canopies affect the thermal regime of permafrost by shading the ground in summer and trapping insulative snow in winter, and shrub expansion often reduces the abundance of lichens. Lichens are a primary winter forage for caribou (Macander et al. 2017).

The categorical vegetation map assigns vegetation cover percentages by vegetation classification. The tundra PFTs mapping models cover by plant types. Predominate PFT within the mapped portion of the Sale Area are dwarf evergreen shrubs (34 percent), sedges (29 percent), and low and tall shrubs (23 percent). PFT models indicate more area of bare ground (5 percent), lichens (11 percent), and water (3 percent) in the Sale Area compared to the statewide vegetation cover map summarized in Table 4.1 (Macander et al. 2017).

Foliar cover models indicate that the sedges tussock cotton-grass covers 25 percent and water sedge covers 5 percent of the Sale Area. Tussock sedge is a preferred late spring forage for caribou and ptarmigan. The evergreen shrubs marsh Labrador-tea covers 12 percent and low-bush cranberry covers 11 percent, while the deciduous shrub diamond-leaf willow covers 11 percent of the mapped portion of the Sale Area. Low-bush cranberries provide forages for small mammals and birds in summer, and ptarmigan and caribou through the winter. Willows are preferred late spring and summer forage for caribou and ptarmigan (Nawrocki et al. 2020).

b. Rare Ecosystems

Rare ecosystems support unique assemblages of flora and fauna within a small geographic area or a restricted range. In Alaska, remoteness preserves many rare ecosystems, although some naturally-uncommon ecosystems are in decline due to their intrinsic vulnerabilities or external threats (Boggs, Flagstad, Boucher, et al. 2019). Ecosystems of conservation concern that occur within the Sale Area include Arctic Pingos and Arctic Inland Dunes. In addition, there is a potential that undiscovered geothermal springs may occur within the Sale Area based on the numerous springs occurring along the eastern Sale Area boundary (Kane et al. 2013), and the presence of a geothermal spring north of the east end of the Sale Area (Figure 4.2).

i. Arctic Pingos

Pingos are perennial, ice-cored domes of soil and vegetation, an estimated 1,500 pingos occur in Alaska, primarily on the coastal plain. Pingos vary in size and shape, and height varies by type with steep-sided pingos averaging 13 feet, broad-based pingos averaging 16 feet, and undetermined pingos averaging 23 feet. Pingos may reach heights of up to 49 feet. Five pingos occur on state-owned lands in the Sale Area. Pingos support unique plant associations, soils, and rare plants. Humans use pingos as survey points, benchmarks, and for radio towers. Brown bears *Ursus arctos* are attracted to pingos because of the high densities of ground squirrels, and caribou use pingos for mosquito relief. Snowy owls *Bubo scandiacus*, rough-legged hawks *Buteo lagopus*, peregrine falcons *Falco peregrinus*, and golden eagles *Aquila chrysaetos* use pingos for perching and hunting. Pingos are likely to be impacted by climate change, because minor changes in climate may cause instability and melting of their ice cores (Walker et al. 1985; Boggs, Flagstad, Boucher, et al. 2019).
**ii. Arctic Inland Dunes**

Active inland dunes in arctic Alaska occur where wind-deposited silts and sands form expansive deposits, along lake and river bluffs, river floodplains, slopes above drained lakes, deltas and ancient moraines. Two arctic inland dune areas occur near the southeastern border of the Sale Area, one on Native Corporation lands and one on state-selected lands managed by BLM. Several imperiled plants are known from inland dune systems. Caribou use dune area for insect relief and ground squirrels use dunes for burrowing. Dune ridges provide naturally elevated, dry corridors that are used preferentially by all-terrain vehicles and snowmachines. Dunes are susceptible to infestation by invasive plants, and are vulnerable to climate change through deepening of the permafrost active layer and associated changes in vegetation cover and soils (Boggs, Flagstad, Boucher, et al. 2019).

**iii. Geothermal Springs**

Geothermal springs are sensitive habitats that support rare and disjunct populations of plants and thermophilic microbes. Fewer than 150 geothermal springs are known in Alaska. Geothermal springs create small, isolated microclimates where soil, water and air temperatures are significantly warmer and more moderate than the surrounding area. Geothermal heating may promote lush growth of vegetation, often supporting plants typical of warmer soils and more southerly regions. In the arctic, geothermal springs may be indicated by groves of balsam poplar *Populus balsamifera* surrounded by tundra (Boggs, Flagstad, Boucher, et al. 2019).
Figure 4.2.—Rare ecosystems in the Sale Area.

Source: (Boggs, Flagstad, Boucher, et al. 2019)
2. Freshwater Habitats

Foothills watersheds are dominated by permafrost and snowmelt runoff that create surface storage as lakes, wetlands, and streams. Hills and valleys better define drainages, with fewer lakes and ponds than within the coastal plain. Freshwater habitats within and adjacent to the Sale Area include wetlands; tundra, mountain and foothill streams; lakes and seasonal ponds. Oxbow lakes along major streams are the predominate type of lakes in the region (Gallant, A. L. et al. 1995). Wetlands and waters cover 26.4 percent of the Sale Area, with wetlands covering 24.3 percent and waters covering 2.1 percent of the Sale Area (Boggs, Flagstad, Aisu, et al. 2019).

a. Wetlands and Waters

Permafrost in the foothills prevents surface drainage resulting in areas of saturated soils during the growing season (Nowacki et al. 2001). Thick organic soil horizons, peat, accumulates due to the persistent freezing temperatures and often anaerobic conditions that retard decomposition by soil microbes and organisms. Various systems have been used to classify wetland soils, vegetation, and supporting hydrology in the Sale Area. Predominant wetland classes in the Sale Area based on the National Wetlands Inventory classes are freshwater emergent and freshwater shrub wetlands (Table 4.2 and Figure 4.3). Wetlands and waters are less prominent in the Sale Area at 26.4 percent cover than across the Arctic Ecoregion at 40.3 percent cover. Emergent (21.9 percent) and shrub wetlands (12.4 percent) are the predominate wetland classes in the Arctic Ecoregion (Flagstad et al. 2018).

Table 4.2.—Wetlands and waters within the Sale Area.

<table>
<thead>
<tr>
<th>Land Cover Class</th>
<th>Description</th>
<th>Approximate Area (acres)</th>
<th>Area Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater Bryophyte</td>
<td>Mosses or lichens cover at least 30% of substrates</td>
<td>61</td>
<td>0.0%</td>
</tr>
<tr>
<td>Freshwater Emergent Wetlands</td>
<td>Perennial, emergent plants cover at least 30%</td>
<td>1,128,169</td>
<td>15.1%</td>
</tr>
<tr>
<td>Freshwater Shrub Wetlands</td>
<td>Woody plants less than 20 feet tall cover at least 30%</td>
<td>691,726</td>
<td>9.2%</td>
</tr>
<tr>
<td>Freshwater Pond</td>
<td>Small, shallow, permanent, or intermittent waterbodies</td>
<td>15,642</td>
<td>0.2%</td>
</tr>
<tr>
<td>Lake</td>
<td>Waterbody 20 acres or larger</td>
<td>29,098</td>
<td>0.4%</td>
</tr>
<tr>
<td>Riverine</td>
<td>Waterbody within a channel</td>
<td>113,995</td>
<td>1.5%</td>
</tr>
<tr>
<td>Uplands</td>
<td>Regions not classified as wetlands; may contain wetlands too small to be differentiated or not detected in imagery</td>
<td>5,508,675</td>
<td>73.6%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7,487,367</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: (Flagstad et al. 2018)
Figure 4.3.—Wetlands and waters in the Sale Area.
b. Streams

Streams in the Brooks Foothills provide migratory routes, foraging habitat, spawning and rearing habitats, and overwintering habitat for fish, and riparian areas provide habitats and travel corridors for terrestrial wildlife (ADF&G 1986c, 2015b). Mountain streams originate in the Brooks Range, flow is from both surface runoff and perennial springs, and most runoff is from snow and ice melt with peak discharges occurring in late May or early June (Moulton and George 2000). The three largest rivers flowing through the Sale Area are the Colville, Sagavanirktok, and Kuparuk rivers (McClelland et al. 2014). Over half of the total discharge from these rivers occurs over about 2 weeks of high spring flows (McClelland et al. 2014). The Colville and Sagavanirktok rivers are mountain streams, while the Kuparuk River is a large tundra stream that drains the Brooks Range foothills and coastal plain (Moulton and George 2000). Tundra streams drain tundra covered slopes of the foothills and coastal plain, tend to be short and meandering, and are often beaded with pools connected by narrow channels (Moulton and George 2000; Arp et al. 2012).

Streams provide migration pathways, warm temperatures, and abundant drift invertebrates for fishes in summer, and deep pools and springs are important for overwintering (Moulton and George 2000). Riparian zones provide the interface between terrestrial and aquatic habitats, and like all edge habitats, they support a wide diversity of wildlife. Riparian zones also filter sediment, reduce the effects of the wind, regulate water temperature, and stabilize stream banks. Riparian areas along rivers and streams support preferred forage plants and prey for brown bears, denning habitat for brown bears, and travel corridors for wolves, bears, moose, and caribou (Truett and Johnson 2000).

c. Lakes and Ponds

Lakes and ponds provide spawning, rearing, and overwintering habitats for fish; nesting, foraging, and escape habitats for birds; and freshwater and riparian foraging habitats for terrestrial mammals (ADF&G 2015b). Lakes cover about 0.4 percent and ponds cover about 0.2 percent of the Sale Area (Table 4.2). Of the water bodies in the Sale Area, many are shallow and freeze to the bottom during the winter (Grunblatt and Atwood 2014), making them unsuitable as overwintering habitat for fish. Late winter unfrozen water may persist in about a third of Sale Area waterbodies, covering about 18 percent of available summer surface water (Grunblatt and Atwood 2014). Recent efforts at lake classification in the Fish Creek watershed on the coastal plain, just west of the Colville River and northwest of the Sale Area, identified lake types as: thermokarst (thaw) and depression lakes, remnant ponds at the margins of drained lake basins, oxbow lakes, and river delta lakes (Jones et al. 2017).

Water depth and presence or absence of emergent vegetation have the greatest influence on zooplankton and benthic invertebrate communities (Howard et al. 2000). Ponds shallower than 5.5 feet freeze to the bottom over winter. Deeper ponds and lakes may retain water beneath the ice that may sustain overwintering fish, but deeper ponds and lakes thaw and warm more slowly decreasing their overall productivity (Howard et al. 2000). Emergent vegetation provides food and substrates that influence invertebrate community composition and abundance, such that shallower ponds generally have a larger plant biomass and invertebrate productivity per unit area than do deep ponds and lakes (Howard et al. 2000). Water fleas Daphnia spp. and fairy shrimp Brachinecta spp. and Polyartemiella spp. are common zooplankton, while midge larvae (chironomids) generally dominate the benthic invertebrate community in arctic ponds (Howard et al. 2000). Fish and birds are the primary consumers of aquatic invertebrates. Loons, ducks, and shorebirds depend on freshwater invertebrates for nutrition during nesting, brood rearing, and migration staging. Predation by fish generally reduces the overall body size of zooplankton as fish preferentially feed on larger zooplankton leaving a prevalence of smaller species (Howard et al. 2000; Laske et al. 2017; Beaver et al. 2019).
Lake connectivity to adjacent drainages may be isolated, ephemeral, or perennial; with shallow, isolated lakes used by the fewest fishes and deep, perennial lakes used by the most fishes (Hershey et al. 2006; Laske et al. 2016; Jones et al. 2017). Surface water connectivity influences fish community composition of lakes as well as distributions of individual species (Hershey et al. 2006; Laske et al. 2016). Perennial channel connection was the primary factor affecting fish community richness likely acting through colonization potential. In lakes without a perennial connection, fish community richness increased with the availability of overwintering habitat and potential for ephemeral connections during the spring freshet (Laske et al. 2016; Jones et al. 2017). The distribution of fishes in foothills lakes is influenced by landscape-scale variables that control fish access (colonization) and survival (extinction) within a lake (Hershey et al. 2006). The importance of extinction versus colonization varies by species based on their ecological differences, with extinction most important for lake trout and slimy sculpin, a mix of extinction and colonization most important for arctic char, and colonization most important for arctic grayling and round whitefish (Hershey et al. 2006).

3. Designated Habitat Areas

Federally-designated habitat areas within and adjacent to the Sale Area include the Arctic National Wildlife Refuge (ANWR) and Gates of the Arctic National Park and Preserve (GAAR). Portions of ANWR and GAAR adjacent to the Sale Area and are discussed below. Essential Fish Habitat within and adjacent to the Sale Area are designated for anadromous streams that support pink and chum salmon. There are no state designated habitat areas within the Sale Area.

a. Arctic National Wildlife Refuge

Extending along the entire stairstep eastern boundary of the Sale Area, ANWR was originally established as the 8.9-million-acre Arctic National Wildlife Range in 1960 by Public Land Order 2214 to preserve the unique wildlife, wilderness, and recreational values. In 1980, the Alaska National Interest Lands Conservation Act (ANILCA; Public Law 96-487) added 9.1 million acres of adjoining public land to the original designation and renamed the area from Range to Refuge. Currently, ANWR includes more than 19 million acres, and is managed by the United States Fish and Wildlife Service (USFWS) which works to conserve animals and plants in their natural diversity, ensure a place for hunting and gathering activities, protect water quality and quantity, and fulfill international wildlife treaty obligations (USFWS 2013). The Tax Cuts and Jobs Act of 2017 (Pub. Law 115-97) required the Bureau of Land Management (BLM) to establish and administer an oil and gas leasing program for the 1.5-million-acre Coastal Plain of ANWR. The ANWR Coastal Plain was set aside by Congress under Section 1002 of ANILCA because of the area’s potential for oil and gas and its importance as wildlife habitat. Section 1002 directs a comprehensive and continuing inventory and assessment of fish and wildlife resources; an analysis of impacts from oil and gas exploration, development, and production; and authorization of oil and gas exploration of the Coastal Plain.

b. Gates of the Arctic National Park and Preserve

Along the southern boundary of the Sale Area, GAAR was established in 1980 under ANILCA to preserve a vast and undeveloped landscape that provides opportunities to experience solitude, the natural environment, and the scenic beauty of the central Brooks Range. GAAR covers nearly 8.5 million acres, with nearly 86 percent of the park designated as Wilderness. GAAR is managed to protect habitat and populations of fish and wildlife including caribou, brown bears, Dall sheep, moose, wolves, and raptors (NPS 2017).
c. Essential Fish Habitat

The National Marine Fisheries Service (NMFS) defines areas of Essential Fish Habitat (EFH) for federally managed fisheries in Alaska as required by 1996 revisions to the Magnuson-Stevens Act (NOAA Fisheries 2018b). EFH is habitat necessary for spawning, breeding, feeding or growth to maturity for fishes managed under federal fishery management plans. Federal agencies must consult with NMFS regarding any action authorized, funded, or undertaken or proposed to be authorized, funded, or undertaken that may adversely affect EFH. While state agencies are not required to consult on EFH, NMFS must provide conservation recommendations on any state action that would adversely affect EFH (NOAA Fisheries 2018a).

Text descriptions and maps are available that identify EFH for each life stage of fish under federal management (NOAA Fisheries 2018b). EFH for fishes covered by the Salmon Fisheries Management Plan (NPFMC et al. 2012) occur within or near the Sale Area. Marine and freshwater EFH for Pacific salmon is identified in the Salmon Fisheries Management Plan (NPFMC et al. 2012; NMFS 2017), freshwater EFH for Pacific salmon is regularly updated in ADF&G’s Anadromous Waters Catalog (Giefer and Blossom 2020). Waters with EFH for Pacific salmon that flow through the Sale Area are listed in Table 4.3.

Table 4.3.—Freshwater EFH for Pacific salmon within or near the Sale Area.

<table>
<thead>
<tr>
<th>Water Name</th>
<th>Water Number</th>
<th>EFH Species</th>
<th>Life Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivishak River</td>
<td>330-00-10360-2251</td>
<td>Chum</td>
<td>present</td>
</tr>
<tr>
<td>Sagavanirktok River</td>
<td>330-00-10360</td>
<td>Chum, Pink</td>
<td>present</td>
</tr>
<tr>
<td>Itkillik River</td>
<td>330-00-10700-2151</td>
<td>Chum, Pink</td>
<td>Chum present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chum</td>
<td>spawning</td>
</tr>
<tr>
<td>Chandler River</td>
<td>330-00-10700-2265</td>
<td>Chum</td>
<td>present</td>
</tr>
<tr>
<td>Killik River</td>
<td>330-00-10700-2365</td>
<td>Chum</td>
<td>present</td>
</tr>
<tr>
<td>Colville River</td>
<td>330-00-10700</td>
<td>Chum, Pink</td>
<td>Chum present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chum</td>
<td>spawning</td>
</tr>
</tbody>
</table>

Source: (Giefer and Blossom 2020)
Notes: Waters ordered east to west.

B. Fish and Wildlife Populations

The primary use of fish and wildlife populations of the Sale Area is subsistence harvest. The following discussions focus on subsistence, and ecologically important fish and wildlife resources that may be susceptible to cumulative effects from post-disposal oil and gas exploration and development within the Sale Area.

Rivers and lakes in the Sale Area support a mix of anadromous and freshwater fishes many of which move seasonally between overwintering habitats in lakes and river pools; summer foraging habitats in streams, rivers, ponds, lakes, and nearshore Beaufort Sea waters; and spawning habitats in streams and rivers. Overwintering habitats are critical for sustaining fish populations in the Arctic (Reynolds 1997). In addition, seasonally flowing streams and emergent wetland connections are used by arctic fish to access and use temporary aquatic habitats that are seasonally frozen and not widely recognized as important fish habitat (Heim et al. 2019; Arp et al. 2019). Aquatic and
terrestrial habitats in the Sale Area support migratory waterbird and landbird nesting and foraging from spring through fall; although most occur in much lower densities than on the coastal plain to the north (Bart et al. 2012). A few landbirds use the foothills year-round. Riparian corridors and tundra vegetation in the Sale Area provide movement corridors and forage for large and small terrestrial mammals and well drained bluffs and ridges support denning, burrowing, and nesting habitat for large and small mammals and raptors.

1. Fish

A total of 16 anadromous and resident freshwater fish species in 5 families have been documented in the Sale Area (ADF&G 2020a; Giefer and Blossom 2020). Forage fish such as ninespine sticklebacks Pungitius pungitius and slimy sculpin Cottus cognatus play a key role in the Arctic as consumers of primary and secondary productivity transferring energy as prey to fish, waterbirds, seabirds, and humans (Parker and Huryn 2013). Key subsistence and sport harvest fish in the Sale Area include whitefish Coregonus spp. and Prosopium cylindraceum, arctic grayling Thymallus arcticus, Pacific salmon Onchorhynchus spp., Dolly Varden Salvelinus malma, arctic char Salvelinus alpinus, lake trout Salvelinus namaycush, and burbot Lota lota (NSBDWM 2018; Scanlon 2018).

Three principal life history patterns are used by Sale Area fishes (Table 4.4):

- **Anadromous** – spawning, hatching, initial rearing in freshwater river systems, before migration to marine waters where they spend most of their lives before returning as adults to freshwater to spawn.

- **Amphidromous** – spawn and overwinter in rivers and streams, migrate to coastal waters to feed each summer, some populations may remain entirely in freshwater.

- **Freshwater** – primarily remain in rivers, streams, or lake systems year-round, may occasionally use brackish coastal areas.

Key fishes in the Sale Area all exhibit a degree of tolerance to brackish water conditions. Table 4.4 summarizes population attributes for key fishes of the Sale Area. Relative abundance, expressed as very abundant, abundant, common, or rare, expresses the contribution of the population to the fish community. Trends were estimated based on reported increases in abundance (for example, Pacific salmon) or summaries from long-term monitoring. Resilience, expressed as low, medium, or high, is an expression of the ability of a population to recover after a disturbance. Recovery is based on the species intrinsic rate of growth, age at maturity, maximum age, and fecundity and is estimated based on the time required for a population to double in size where high = <15 months, medium = 1.4 to 4.4 years, and low = 4.5 to 14 years for population doubling (Love et al. 2016).
### Table 4.4.—Attributes of key fish populations of the Sale Area.

<table>
<thead>
<tr>
<th>Common Inupiat Scientific Names</th>
<th>Relative Abundance and Trends</th>
<th>Population / Stock</th>
<th>Population Resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broad Whitefish</td>
<td>Common – Rare in marine waters Declining</td>
<td>Amphidromous Colville, Sagavanirktok stocks for spawning, overwintering</td>
<td>Low: Double – 4.5-14 years Maturity – 7 years Fecundity – 10,000 eggs</td>
</tr>
<tr>
<td>Coregonus nasus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humpback Whitefish</td>
<td>Common – Uncommon in marine waters Stable</td>
<td>Amphidromous Some distinct populations in Beaufort drainages</td>
<td>Low: Double – 4.5-14 years Maturity – 3-14 years Fecundity – 8,000 eggs</td>
</tr>
<tr>
<td>Pikuktuuq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coregonus pidschian</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round Whitefish</td>
<td>Uncommon</td>
<td>Freshwater</td>
<td>Low: Double – 4.5-14 years Maturity – 5-7 years Fecundity – 1,000 eggs</td>
</tr>
<tr>
<td>Savigunnaq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propopium cylindraceum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arctic Grayling</td>
<td>Abundant</td>
<td>Freshwater</td>
<td>Medium: Double – 1.4-4.4 yrs Maturity – 2-6 years Fecundity – 416 eggs</td>
</tr>
<tr>
<td>Sulukpauaq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thymallus arcticus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chum Salmon</td>
<td>Common Increasing</td>
<td>Anadromous Mackenzie River EFH – spawning</td>
<td>Medium: Double – 1.4-4.4 yrs Maturity – 2-5 years Fecundity – 900-8,000 eggs</td>
</tr>
<tr>
<td>Iqalugruaq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onchorhynchus keta</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pink Salmon</td>
<td>Common – East to Simpson Lagoon Increasing</td>
<td>Anadromous EFH – spawning</td>
<td>Medium: Double – 1.4-4.4 yrs Maturity – 2 years Fecundity – 800 eggs</td>
</tr>
<tr>
<td>Amaqtuuq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onchorhynchus gorbuscha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolly Varden</td>
<td>Common – widely distributed, rivers Stable</td>
<td>Amphidromous Multiple – overwinter in Canning, Sagavanirktok, Colville</td>
<td>Low: Double – 4.5-14 years Maturity – 3-5 years Fecundity – 1,500-7,000 eggs</td>
</tr>
<tr>
<td>Iqalukpik</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvelinus malma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arctic Char</td>
<td>Uncommon – Brooks Range lakes Stable</td>
<td>Freshwater</td>
<td>Low: Double – 4.5-14 years Maturity – 7-10 years Fecundity – 400 eggs</td>
</tr>
<tr>
<td>Iqaluqpak</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvelinus alpinus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake Trout</td>
<td>Common – widely distributed, lakes Stable</td>
<td>Freshwater</td>
<td>Low: Double – 4.5-14 years Maturity – 5-20 years Fecundity – 5,000 eggs</td>
</tr>
<tr>
<td>Iqaluaqpak</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvelinus namaychush</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burbot</td>
<td>Uncommon</td>
<td>Freshwater</td>
<td>Low: Double – 4.5-14.0 yrs Maturity – 6-7 years Fecundity – 970,000 eggs</td>
</tr>
<tr>
<td>Tittaaliq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lota lota</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ninespine Stickelback</td>
<td>Common</td>
<td>Freshwater</td>
<td>Medium: Double – 1.4-4.4 yrs Maturity – 1-2 years Fecundity – 350 eggs</td>
</tr>
<tr>
<td>Kakaliqauraq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pungitius pungitus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slimy Sculpin</td>
<td>Abundant – widely distributed Unknown</td>
<td>Freshwater</td>
<td>Medium: Double – 1.4-4.4 yrs Maturity – 2-4 years Fecundity – 42-1,420 eggs</td>
</tr>
<tr>
<td>Kanayuq</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cottus cognatus</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: (Roach and Evenson 1993; Brown 2008; Carothers et al. 2013; Dunmall et al. 2013; Love et al. 2016; Froese and Bailey 2018; Froese and Ortañez 2018; Luna 2019; ADF&G 2020e)

Notes: yrs = years; see text for definitions of relative abundance and population resilience.

### a. Whitefish

Whitefish commonly harvested by subsistence fisheries that occur in the Sale Area include: broad whitefish, humpback whitefish, and round whitefish (Moulton et al. 2010; NSBDWM 2018). Whitefish are among the most common fishes in the region and use essentially every habitat, summering in coastal brackish waters, rivers, streams and lakes; spawning in rivers, streams, or
lakes; and overwintering in either freshwaters or brackish water in large river deltas (Morris 2006; McCain et al. 2014). Life histories are similar and primarily amphidromous which enables whitefish to take advantage of the productive estuarine habitats in Beaufort Sea coastal waters during summer (McCain et al. 2014; Love et al. 2016). Seasonal movements are similar among the whitefishes, although the degree of salinity tolerance determines their extent of intrusion into marine waters (Thorsteinson and Love 2016). In general, humpback whitefish tolerate higher salinities than broad whitefish and round whitefish are the least tolerant. Amphidromous fishes generally live longer, grow more slowly, and mature later than anadromous fishes, making them generally less resilient to changes in environmental conditions (Love et al. 2016; Thorsteinson and Love 2016).

Broad whitefish spawning populations are known from the Colville and Sagavanirktok rivers (Love et al. 2016). In the Sale Area broad whitefish have been documented in the Colville River and its tributary the Chandler River (Giefer and Blossom 2020; ADF&G 2020a). Broad whitefish broadcast spawn in rivers over gravel substrates during October and November. Eggs hatch in the spring and juvenile broad whitefish are flushed into river deltas and lakes to rear (Love et al. 2016). By September juveniles and adults have returned to rivers, where they disperse to overwintering habitats in river deltas, deep river pools, and lakes (Love et al. 2016).

Humpback whitefish spawning areas occur in the Colville River (McCain et al. 2014; Love et al. 2016). In the Sale Area humpback whitefish have been documented in the Colville River and its tributary the Chandler River (Giefer and Blossom 2020). Humpback whitefish broadcast spawn in slow to moderate flow rivers often within a few miles of the river mouth over gravel or sand substrates during September to October. Eggs hatch in late-winter to spring and juvenile humpback whitefish are carried downstream to the lower parts of rivers and brackish coastal waters to rear (Love et al. 2016). Adults begin returning to rivers in June with peak returns likely in August, and overwinter in brackish river delta waters and perhaps in freshwater (Love et al. 2016).

Round whitefish have been documented from Colville River watershed streams and lakes in the Sale Area and they are captured in nearshore waters in the Sagavanirktok River delta (McCain et al. 2014; McCain and Raborn 2016; ADF&G 2020a). Round whitefish spawn in shallow waters of streams and lakes during fall and early winter (Hauser 2011).

b. Arctic Grayling

Arctic grayling are widespread in ponds, lakes, and streams across the Sale Area (ADF&G 2020a). Populations across the North Slope likely intermix, but all are dependent on available deep areas within rivers or lakes for overwintering habitat (Reynolds 1997; Moulton and George 2000). Although arctic grayling are considered freshwater resident fish, they make extensive movements both within and between freshwater stream and lake systems (Morris 2003), including excursions into and through estuarine coastal waters (Heim, Whitman, et al. 2016). Shortly after breakup, adult arctic grayling move from overwintering areas into tributary streams to spawn over sand or grave substrates, while juveniles move to foraging habitats (Heim, Wipfli, et al. 2016). Eggs develop within about 3 weeks, and young-of-the-year grayling feed through the summer, then move into rivers or lakes for overwintering. Juvenile fish move from wintering areas in spring, and adults move from spawning areas into small streams, lakes, shallow areas in rivers, or freshened coastal waters for feeding. As salinity increases in coastal waters later in summer, juvenile and adult grayling using coastal waters returning to streams and rivers may have dispersed considerable distances (Moulton and George 2000). Arctic grayling show some site fidelity for overwintering habitats. Adult and larger juvenile migration is triggered by decreasing stream flows during late-June to early-July, while smaller juvenile migration occurs in two peaks one in July during high
flows and high stream temperatures and one in September shortly before freeze up during very low flows (Heim, Wipfli, et al. 2016).

c. Pacific Salmon

While chum, pink, Chinook *Oncorhynchus tshawytscha*, and coho salmon *O. kisutch* have been reported from the Beaufort Sea for more than a century, they are rare by comparison to the more abundant whitefish and Dolly Varden, and are generally considered strays from southern populations with no definitive proof for self-sustaining spawning populations (Carothers et al. 2013; Nielsen et al. 2013; McCain et al. 2014). Pink and chum salmon are the only salmon known to spawn in Sale Area drainages, with only chum salmon spawning in the Sale Area (see Table 4.3). Increases in adult salmon captured in arctic waters have been attributed to the changing climate (Dunmall et al. 2013; Nielsen et al. 2013). Salmon are anadromous, spawning in freshwater and rearing in freshwater and marine habitats. Pink and chum salmon are the most cold tolerant of the Pacific salmon, and complete the majority of their life cycle in marine waters (Irvine et al. 2009).

After hatching and emerging from spawning gravels, pink smolts usually move to estuaries within days while chum smolts may remain in freshwater for a month or more (Love et al. 2016).

Chinook salmon usually spawn in headwater streams and rear in freshwaters for several years. Juvenile Chinook and coho salmon have been documented in the Sale Area from the Colville River (ADF&G 2020a). Chinook and coho salmon are not discussed here as they rarely occur within the Sale Area.

Spawning chum salmon have been observed in the Colville and Iltkillik rivers within the Sale Area (Carothers et al. 2013; Nielsen et al. 2013; Giefer and Blossom 2020). Populations in nearshore and offshore waters may originate from local spawning stocks or may belong to the Mackenzie population. Mackenzie River chum spawn during the fall with spawning runs occurring in July and August (Love et al. 2016). Spawning habitats include gravels in streams and rivers where females dig redds; usually further upriver than pink salmon in reaches associated with groundwater upwelling. After their spring emergence, juveniles have a short freshwater residency, remain in fresh water for up to several weeks or moving directly to nearshore waters. They may form loose aggregations in estuaries and nearshore waters for several months before moving offshore. Age at maturity is variable ranging from 2 to 6 years, with most chum maturing and spawning at 3 years (Love et al. 2016). Overwintering areas are unknown but potentially could occur in the Bering Sea, Beaufort Sea deep water under the pack ice, or under ice in the Mackenzie River plume (Irvine et al. 2009).

Spawning pink salmon have been observed in the Colville, Kuparuk, and Sagavanirktok river drainages downstream from the Sale Area (Carothers et al. 2013; Nielsen et al. 2013; Giefer and Blossom 2020). Pink salmon spawn, generally during July to October, in the lower reaches of streams and rivers sometimes into intertidal reaches. Pink salmon have a 2-year life cycle, with spawning runs in even years near Prudhoe Bay (McCain et al. 2014). After their emergence in June to early July, juveniles have a short freshwater residency, remaining in fresh water for only a few days prior to or moving directly to nearshore waters (Love et al. 2016). Fry may school in the lower reaches of rivers, while juveniles usually school after moving into nearshore waters.

d. Char

Char are distinguished from salmon and trout by their smaller scales and light colored or red spots over a darker background. Dolly Varden and arctic char were once considered a single species complex (Taylor, E. B. 2016). They are difficult to distinguish because their appearance can be quite variable, their ranges overlap, and both have alternate life forms including: anadromous, freshwater resident, and dwarf. All char spawn in the fall (Hauser 2011).
Dolly Varden spawning populations in the Sale Area occur in the Colville, Sagavanirktok, and Canning river drainages (Brown et al. 2018; Giefer and Blossom 2020). Dolly Varden construct redds and spawn in gravels associated with perennial springs primarily during September and October. While they are capable of spawning multiple times during their lives, they rarely spawn in successive years (Brown et al. 2018). After spawning most post-spawning adults move downstream to overwintering areas (Brown et al. 2018). Eggs hatch and fry emerge from the gravels 9 to 11 months later (Love et al. 2016). Juvenile fish rear in freshwater for 1 to 5 years before beginning their initial seaward migration in mid-June (Brown et al. 2018). Fish return to rivers during July through September (Brown et al. 2018). Once in coastal waters, Dolly Varden use both nearshore and offshore habitats during summer foraging, generally remaining in relative shallow water (Courtney et al. 2018). Dolly Varden size has increased during 1969 to 2015 in Beaufort Sea consistent with increased maximum size in other Arctic vertebrates in Alaska and Canada due to longer growing seasons, and increased prey abundance, quality, or diversity (Courtney et al. 2019). In the Canning River, overwintering occurs in both the upper and lower river, as well as in association with perennial springs, with most post-spawning adults overwintering in the same main-stem areas as non-spawning adults (Brown et al. 2018). Dolly Varden from multiple spawning areas may overwinter together and straying rates between overwintering areas are nearly 40 percent (Brown et al. 2018).

Arctic char in northern Alaska are lake residents, spawning, overwintering, and foraging in lakes. Near the Toolik Field Station in the Sagavanirktok, Kuparuk, Toolik, and Itkillik river drainages, arctic char are predicted to occur in lakes at elevations greater than 2,740 feet with depths greater than 22 feet; with presence correctly predicted 92 percent and absence correctly predicted 83 percent of the time (Hershey et al. 2006). Arctic char spawn on gravel shoals or in small streams adjacent to lakes. Males establish territories that are defended against other fish. Females dig redd within a male’s territory. Eggs hatch in about 2 months, usually before spring, and young begin feeding after emerging from the gravel. Arctic char feed on zooplankton, aquatic insects, and other fish depending upon age, size, and season (ADF&G 2020b).

Lake trout are also lake residents, found in deeper lowland lakes along the central coastal plain, and clear mountain lakes in the Brooks Range. For lakes near the Toolik Field Station in the Sagavanirktok, Kuparuk, Toolik, and Itkillik river drainages, lake trout are predicted to occur in lakes deeper than 22 feet with perimeters greater than 22 feet; with presence correctly predicted 85 percent and absence correctly predicted 75 percent of the time (Hershey et al. 2006). Growth varies depending on diet, water temperature, altitude and genetics – but lake trout are Alaska’s largest freshwater fish, reaching nearly 50 pounds. They can live more than 50 years, although their typical maximum age is about 20 years. They broadcast spawning during nights in September and October over cleaned, rocky lake bottoms. Eggs hatch the following spring and young lake trout feed on plankton during the first few years. Lake trout feed on zooplankton, aquatic insect larvae, small crustaceans, clams, snails, leeches, fish, mice, shrews, and occasionally young birds. Where available, lake trout may feed extensively on whitefish, arctic grayling, sticklebacks, and sculpins (ADF&G 2020e).

e. Burbot

Burbot are the only freshwater member of the cod family (Gadidae). Burbot retain characteristics of the cods preferring cool and cold waters, spawning at low temperatures in large schools with random dispersal of gametes and high fecundity (Stapanian et al. 2010). They are long lived, late maturing, nocturnal and crepuscular fish that spawn under the ice during February to March. Eggs are small and semi pelagic, hatching within 40 to 70 days (Luna 2019). Larvae float below the surface feeding on drifting invertebrates or zooplankton, sinking to benthic habitat after about
2 months (Luna 2019). Young burbot feed on insects and invertebrates, while adult and juvenile burbot are primarily piscivorous feeding on whitefish, sculpins, and other burbot (Gallagher and Dick 2015; ADF&G 2020c). Adults and juveniles move between stream and lake habitats for foraging and overwinter in deep pools in river channels and lakes with strong connections to river systems (Morris 2003; Arp et al. 2019).

f. Forage Fish

Forage fish transfer primary and secondary productivity within food webs that support fish and wildlife populations used for subsistence and sport harvest (Parker and Huryn 2013; Laske et al. 2018; Hanson et al. 1992). Important forage fishes in the Sale Area include ninespine stickleback and slimy sculpin.

**Ninespine sticklebacks** are the most abundant and widespread freshwater fish on the coastal plain, occurring in nearly all lake and stream systems that contain unfrozen water through winter (Moulton and George 2000; Laske et al. 2016). They also live in benthic and midwater marine and estuarine habitats, including under sea ice, making excursions as far as 4 miles offshore in the Beaufort Sea (Love et al. 2016). During summer, sticklebacks occupy shallow, vegetated, low-velocity waters such as the edges of lakes, ponds, and pools in beaded streams (Moulton and George 2000). Spawning occurs in late June and early July (Love et al. 2016). Males establish breeding territories, construct nests, and protect eggs and fry. In fall, fish move to deeper waters for overwintering, including river deltas, rivers, and lakes.

**Slimy sculpins** are widely distributed in streams and lakes throughout the Sale Area (ADF&G 2020a). They are found in rocky riffles of streams and benthic habitats in lakes. They spawn in spring shortly after breakup in shallow waters under a rock or log. The male prepares a nesting spot by removing sediments and debris and establishes a territory that is defended against other males. One or more females lay eggs on the underside of the rock or log. The male fertilizes, cleans, and aerates the eggs and guards the nest until the young fish are ready to leave. Eggs hatch about 30 days after fertilization and sac-fry remain in the nest for about a week. Slimy sculpins feed on insects, but also eat crustaceans, fish eggs, and small fish (ADF&G 2008; Froese and Garilao 2019).

2. Birds

Over 150 species of birds visit the North Slope annually, with more than 100 species nesting, and a few remaining year-round (Huryn and Hobbie 2012). All but the handful of resident birds are migratory, occurring within the Sale Area primarily during early June through September (Johnson, S. R. and Herter 1989).

The most recent 10-year average number of birds per route for the Happy Valley and Galbraith Lake breeding bird survey routes in the Sale Area (Figure 4.4) with their conservation status are summarized in Table 4.5. An average of about 20 and 24 species and about 300 individuals were recorded annually on these 16 and 29-mile routes, respectively (Table 4.5). Key subsistence harvested birds and eggs on the North Slope are geese, swans, eiders, ducks, and seabirds (ADF&G 2015a). The Sale Area and bordering Brooks Range also provide foraging and nesting habitat for golden eagles *Aquila chrysaetos* (Huryn and Hobbie 2012). All migratory birds are protected under the Migratory Bird Treaty Act, and golden eagles are protected under the Bald and Golden Eagle Protection Act.
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Source: (ADF&G 1986c; Audubon Alaska 2015; Pardieck et al. 2019)

Figure 4.4.—Bird survey routes, important bird area, and goose habitat in the Sale Area.
Table 4.5.—Breeding birds documented in the Sale Area, 2008 to 2019.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Happy Valley 2009-2018 Mean</th>
<th>Galbraith Lake 2009-2018 Mean</th>
<th>Species of Greatest Conservation Need Justification</th>
</tr>
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<tbody>
<tr>
<td><strong>Waterfowl</strong></td>
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<tr>
<td>Canada Goose</td>
<td><em>Branta canadensis</em></td>
<td>26.4</td>
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<tr>
<td>Greater White-fronted Goose</td>
<td><em>Anser albifrons</em></td>
<td>5.2</td>
<td>6.5</td>
<td>Sentinel, Cultural</td>
</tr>
<tr>
<td>Tundra Swan</td>
<td><em>Cygnus columbianus</em></td>
<td>0</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Greater Scaup</td>
<td><em>Aythya marila</em></td>
<td>3.7</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>Green-winged Teal</td>
<td><em>Anas crecca</em></td>
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<td>0.3</td>
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<tr>
<td>Long-tailed Duck</td>
<td><em>Clangula hyemalis</em></td>
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<td><em>Anas platyrhynchos</em></td>
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<td>Northern Pintail</td>
<td><em>Anas acuta</em></td>
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<td>0.6</td>
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<tr>
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<td><em>Melanitta perspicillata</em></td>
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<td>White-winged Scoter</td>
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<td>0.9</td>
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<td><strong>Seabirds</strong></td>
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<td>Arctic Tern</td>
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<td>Glaucous Gull</td>
<td><em>Larus hyperboreus</em></td>
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<td>2.8</td>
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<td>Long-tailed Jaeger</td>
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<td><strong>Shorebirds</strong></td>
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<td>American Golden-Plover</td>
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<tr>
<td>Red-necked Phalarope</td>
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<td>1.8</td>
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<tr>
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<td>0</td>
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<td><em>Numenius phaeopus</em></td>
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<td>1.8</td>
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<td><strong>Raptors and Owls</strong></td>
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<td>0.4</td>
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<td><em>Buteo lagopus</em></td>
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<tr>
<td>Short-eared Owl</td>
<td><em>Asio flammeus</em></td>
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<tr>
<td><strong>Ptarmigan</strong></td>
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<td>Rock Ptarmigan</td>
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<td>1.8</td>
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<tr>
<td>Willow Ptarmigan</td>
<td><em>Lagopus lagopus</em></td>
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<td>0</td>
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<td><strong>Passerines</strong></td>
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<td>American Pipit</td>
<td><em>Anthus rubescens</em></td>
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<td>American Robin</td>
<td><em>Turdus migratorius</em></td>
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<tr>
<td>American Tree Sparrow</td>
<td><em>Spizelloides arborea</em></td>
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<td>Arctic Warbler</td>
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<tr>
<td>Bank Swallow</td>
<td><em>Riparia riparia</em></td>
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<td>0</td>
<td>Species of Concern</td>
</tr>
<tr>
<td>Bluethroat</td>
<td><em>Cyanecula svecica</em></td>
<td>0.1</td>
<td>0.1</td>
<td>Stewardship</td>
</tr>
</tbody>
</table>
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The lower Colville River is a continental important bird area for arctic cliff-nesting raptors that include arctic peregrine falcon *Falco peregrinus tundrius*, gyrfalcon *Falco rusticolus*, and rough-legged hawk (Figure 4.4). Eroding cliff faces provide nesting habitat while the surrounding tundra and riparian areas provide foraging habitat. The Colville River and its tributaries are also important breeding habitat for high numbers of trans-Beringian migrant passerines that include eastern yellow wagtail, arctic warbler, and bluethroat. In addition, several shorebirds nest in the wet and moist tundra around the Colville River including American golden plover, red-necked phalarope, Baird’s sandpiper *Calidris bairdii*, semipalmated sandpiper, bar-tailed godwit *Limosa lapponica*, and whimbrel (Audubon 2013).

The information presented below is focused on key bird populations that provide subsistence and sport harvest resources, that depend upon aquatic and terrestrial habitats within the Sale Area, and that may be susceptible to cumulative effects from oil and gas exploration and development. Life history, migration, and population attributes are summarized for some of these key bird populations in Table 4.6 and are discussed below.

### a. Waterbirds

Waterbirds, including geese, swans, ducks, loons, seabirds, and shorebirds use water bodies, and wetlands to varying degrees during portions of their life history. All waterbirds in the Sale Area are migratory because their aquatic habitats are frozen during the winter. The current warming trend in the arctic has moved the transition from winter to summer to occur weeks earlier over the last century and many waterbirds have responded by arriving an average of 6 days earlier from 1964 to 2013 (Ward et al. 2016). All waterfowl – geese, swans, and ducks – go through a flightless molt period, when all flight feathers are shed and regrown. Adult waterfowl typically molt when one (ducks) or both (geese and swans) sexes of a breeding pair are rearing flightless young. Brood-
rearing geese often form large flocks that forage and move together. Post-breeding male ducks and nonbreeding and juvenile waterfowl also form large flocks during molting.

Aerial breeding pair surveys are used to estimate waterfowl population size and trend to set harvest limits. On the North Slope, these annual surveys cover the region with the highest densities of nesting waterfowl, the arctic coastal plain (Wilson, H. M. et al. 2018). The abrupt change in elevation and decreased wetland density between the coastal plain and the foothills, results in generally decreased densities for most waterbirds in the foothills. Some waterbirds, however, appear to increase in abundance at the southern edge of the arctic coastal plain which is the northern limit of their breeding range, and consequently may be more abundant in the foothills including white-winged scoters, greater and lesser scaup *Aythya affinis*, and red-breasted mergansers (Amundson et al. 2019).

### i. Geese and Swans

Geese and swans that nest in arctic Alaska or Canada and use habitats in the Sale Area (Figure 4.4) during the breeding or post-breeding season include: greater white-fronted geese, cackling geese *Branta hutchinsii*, and tundra swans (Pardieck et al. 2019; Huryn and Hobbie 2012). Canada geese reported on the breeding bird survey routes (Table 4.5) could be either Canada or cackling geese. Generally, Canada geese on the North Slope are considered to belong to the smaller cackling goose species, but Canada and cackling goose ranges overlap in the Sale Area. Arctic coastal plain breeding pair surveys, indicate that greater white-fronted goose and tundra swan populations have been increasing while cackling goose populations remained stable from 1986 to 2017 (Wilson, H. M. et al. 2018).

**Greater white-fronted geese** are the most widespread and abundant goose on the North Slope. They nest on sedge or grass tundra next to sloughs, lakes, or ponds. Birds nesting on the North Slope belong to the mid-continent population. The arctic coastal plain breeding population is considered stable, but they may have increased at a rate of about 6 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Molting non-breeding and failed breeding geese from the mid-continent population use habitats north of the Sale Area near Teshekpuk Lake with low-relief lowlands of deep lake basins and extensive meadow-like foraging areas. During migration, greater white-fronted geese use coastal marsh habitats in river deltas and estuaries (Ely et al. 2020). During late-June/early-July, most greater white-fronted geese (85 percent) use shoreline habitats from east of Smith Bay to and including the Sagavanirktok River delta (Dau, C. P. and Bollinger 2012). During the peak molt period in mid-July 2015 to 2017, from 1,800 to over 5,000 greater white-fronted geese used coastal habitats from eastern Smith Bay to western Harrison Bay north of the Sale Area (Shults and Dau 2016; Shults and Zeller 2017, 2018).

**Cackling Geese**, previously considered the small body race of the Canada goose, breed across the North Slope and congregate in coastal areas after breeding. The arctic coastal plain breeding population is stable to increasing at a non-significant rate of about 2 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Cackling geese nest individually or semi-colonially usually near water and they prefer small islands in tundra ponds. Broods are reared in a variety of habitats that include water and exposed mud and aquatic or aquatic-emergent plants (Mowbray et al. 2002). In late-June/early-July, most cackling geese (80 percent) use shoreline habitats north and east of Teshekpuk Lake (Dau, C. P. and Bollinger 2012). During the peak molt period in mid-July 2015 to 2017, from 300 to over 5,000 cackling geese used coastal habitats from eastern Smith Bay to western Harrison Bay north of the Sale Area (Shults and Dau 2016; Shults and Zeller 2017, 2018).
<table>
<thead>
<tr>
<th>Common Scientific Names</th>
<th>Life History</th>
<th>Migration</th>
<th>Population and Trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater White-fronted Goose</td>
<td>Mass: 5-6 pounds</td>
<td>S: late-May – early June</td>
<td>NA: 774,000</td>
</tr>
<tr>
<td>Anser albifrons</td>
<td>Life span: 22 years</td>
<td>M: July</td>
<td>Alaska: 187,500</td>
</tr>
<tr>
<td></td>
<td>Clutch: 4 eggs</td>
<td>F: late Aug – mid-Sep</td>
<td>ACP: 387,991</td>
</tr>
<tr>
<td></td>
<td>Breed: late-May - Aug</td>
<td>AGR: 1.056</td>
<td></td>
</tr>
<tr>
<td>Tundra Swan</td>
<td>Mass: 14-16 pounds</td>
<td>S: mid-May – late May</td>
<td>NA: 194,000</td>
</tr>
<tr>
<td>Cygnus columbianus</td>
<td>Life span: 21 years</td>
<td>M: July – Aug</td>
<td>Alaska:</td>
</tr>
<tr>
<td></td>
<td>Clutch: 3-4 eggs</td>
<td>F: late Sep – early Oct</td>
<td>ACP: 16,735</td>
</tr>
<tr>
<td></td>
<td>Breed: late May – mid-Sep</td>
<td>AGR: 1.021</td>
<td></td>
</tr>
<tr>
<td>Long-tailed Duck</td>
<td>Mass: 1-2.5 pounds</td>
<td>S: early Apr – late May</td>
<td>NA: 2,700,000</td>
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<tr>
<td>Clangula hyemalis</td>
<td>Life span: 20 years</td>
<td>M: late June – Aug</td>
<td>Alaska: 200,000</td>
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<tr>
<td></td>
<td>Clutch: 7 eggs</td>
<td>F: late Oct – late Dec</td>
<td>ACP: 37,855</td>
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<td></td>
<td>Breed: late May – late Aug</td>
<td>AGR: 0.972</td>
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<tr>
<td>Yellow-billed Loon</td>
<td>Mass: 10-13 pounds</td>
<td>S: Apr – July</td>
<td>NA: 24,000</td>
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<tr>
<td>Gavia adamsii</td>
<td>Life span: 10 years</td>
<td>F: mid-Aug – November</td>
<td>Alaska: 3,500</td>
</tr>
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<td></td>
<td>Clutch: 1-2 eggs</td>
<td>ACP: 1,311</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: May – Oct</td>
<td>AGR: 0.994</td>
<td></td>
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<tr>
<td>Glaucous Gull</td>
<td>Mass: 2.8-3.5 pounds</td>
<td>S: Mar – mid-May</td>
<td>Global: 340,000</td>
</tr>
<tr>
<td>Nauuyaq</td>
<td>Life span: 22 years</td>
<td>M: Aug – Sep</td>
<td>Alaska:</td>
</tr>
<tr>
<td>Larus hyperboreus</td>
<td>Clutch: 3 eggs</td>
<td>F: mid-Sep – early Nov</td>
<td>ACP: 100,000</td>
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<tr>
<td></td>
<td>Breed: June – Aug</td>
<td>AGR: 0.973</td>
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<tr>
<td>Long-tailed Jaeger</td>
<td>Mass: 7.1-12.1 ounces</td>
<td>S: late Mar –May</td>
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<td>Isuŋŋa</td>
<td>Life span: 9 years</td>
<td>F: Aug – early Nov</td>
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<td>Breed: late May – Aug</td>
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<tr>
<td>American Golden Plover</td>
<td>Mass: 4.3-6.9 ounces</td>
<td>S: late Jan – late Apr</td>
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<td>Tulik</td>
<td>Life span: 13 years</td>
<td>F: Adult late Jun – Aug</td>
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<tr>
<td>Pluvialis dominica</td>
<td>Clutch: 3-5 eggs</td>
<td>F: Juvenile late Aug – early Oct</td>
<td>FH: 114,500</td>
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<td></td>
<td>Breed: late May – July</td>
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<td>Whimbrel</td>
<td>Mass: 0.7-1.1 pounds</td>
<td>S: Apr – May</td>
<td>NA: 85,000</td>
</tr>
<tr>
<td>Siituvuk</td>
<td>Life span: 12 years</td>
<td>F: mid-Jul – late Aug</td>
<td>Alaska: 40,000</td>
</tr>
<tr>
<td>Numenius phaeopus hudsonius</td>
<td>Clutch: 4 eggs</td>
<td>FH: 1,230</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: late May – Jul</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Gyrfalcon</td>
<td>Mass: 1.8-4.6 pounds</td>
<td>S: Feb – mid Apr</td>
<td>Global: 70,000</td>
</tr>
<tr>
<td>Aaqhaaliq</td>
<td>Life span: 12 years</td>
<td>F: Sep – Oct</td>
<td>Alaska: 1,010</td>
</tr>
<tr>
<td>Falco rusticolus</td>
<td>Clutch: 1-5 eggs</td>
<td>ACP: 180</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: late Apr – early Aug</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Rough-legged Hawk</td>
<td>Mass: 1.6-3.1 pounds</td>
<td>S: Feb – Apr</td>
<td>Global: 500,000</td>
</tr>
<tr>
<td>Qilgiq</td>
<td>Life span: 18 years</td>
<td>F: Aug – Dec</td>
<td>Alaska:</td>
</tr>
<tr>
<td>Buteo lagopus</td>
<td>Clutch: 1-7 eggs</td>
<td>ACP: &gt;400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: late Apr – mid-Aug</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Horned Lark</td>
<td>Mass: 1.0-1.7 ounces</td>
<td>S: Feb – Apr</td>
<td>NA: ~4,000,000</td>
</tr>
<tr>
<td>Eremophila alpestris arctica</td>
<td>Life span: 8 years</td>
<td>F: Sep – Nov</td>
<td>Alaska: 70,000</td>
</tr>
<tr>
<td></td>
<td>Clutch: 2-5 eggs</td>
<td>FH: ?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: May – Jul</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>Smith’s Longspur</td>
<td>Mass: 0.7-1.1 ounces</td>
<td>S: Mar – mid-Jun</td>
<td>Global: 75,000</td>
</tr>
<tr>
<td>Qalguusiqsuq</td>
<td>Life span: 5 years</td>
<td>F: mid-Aug – Nov</td>
<td>Alaska:</td>
</tr>
<tr>
<td>Calcarius pictus</td>
<td>Clutch: 4 eggs</td>
<td>FH: ?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Breed: mid-Jun – Jul</td>
<td>Declining</td>
<td></td>
</tr>
</tbody>
</table>


Notes: Migration: S = spring, M = molt, F = fall, Juv = Juvenile; Population: NA = North America; ACP = arctic coastal plain; FH = foothills; AGR = annual growth rate.
**ii. Ducks**

Greater scaup and long-tailed ducks are the most commonly observed ducks on breeding bird surveys routes in the Sale Area (Table 4.5). Scaup are diving ducks that often use marine habitats during winter, similar to seaducks (tribe Mergani). Greater and lesser scaup are not distinguishable from each other during aerial surveys and are recorded as scaup. Seaducks that use habitats in the foothills include long-tailed ducks, scoters *Melanitta spp.*, red-breasted mergansers, and harlequin ducks *Histrionicus histrionicus* (Huryn and Hobbie 2012). Long-tailed ducks are one of the most abundant breeding ducks on the North Slope. The foothills are at the northern edge of the breeding range for scoters, which primarily nest in boreal forests. Red-breasted mergansers are piscivorous diving ducks that are widely distributed throughout Alaska, nesting in both tundra and boreal forest habitats. Harlequin ducks primarily nest along clear mountain streams but may use rivers and spring-fed streams in the foothills during nesting and brood-rearing. Harlequin ducks dive to river bottoms to pick larval insects from rocky substrates (Huryn and Hobbie 2012). Of the dabbling ducks recorded for survey routes in the Sale Area, green-winged teal were most abundant followed by northern pintail and mallard (Table 4.5).

**Greater scaup** feed on insects, crustaceans, small bivalves, snails, and amphipods, as well as leaves, stems, and seeds of plants during summer. Scaup (combined greater and lesser) coastal plain breeding population is stable to decreasing at a non-significant rate of about 5 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Scaup populations throughout North American have experienced significant declines in recent years, 28 percent below the long-term average (USFWS 2018). Scaup on Alaska’s arctic coastal plain are primarily greater scaup, and areas where greater scaup predominate have experienced less drastic declines than areas where lesser scaup predominate (Amundson et al. 2019; Ross et al. 2015). In Alaska, greater scaup use relatively shallow lakes and large ponds with low surrounding vegetation in wetland complexes with abundant smaller lakes, ponds, and sloughs for breeding. Once incubation begins, males disperse to molt in relatively large, isolated lakes that are used year after year (Kessel et al. 2020).

**Long-tailed ducks** feed on epibenthic crustaceans such as amphipods, mysids, and isopods by diving in the marine environment, and consume larval and adult aquatic insects, amphipods, fairy shrimp, cladocerans, and vegetation in breeding areas on the coastal plain (Robertson and Savard 2002). Their coastal plain breeding population is stable to decreasing at a non-significant rate of about 3 percent per year over the past 10 years (Wilson, H. M. et al. 2018). Long-tailed ducks breed throughout the North Slope and congregate in coastal habitats to stage and molt after breeding (Figure 4.5). Broods are moved to ponds or lakes next to the nest just after hatch, move to nearby lakes and ponds with high densities of invertebrates as ducklings grow, and likely move as invertebrate resources are depleted. Males leave nesting areas first to molt primarily in coastal lagoons although large inland lakes are also used. Spring migration follows open leads and polynyas (Derksen et al. 2015). Tens of thousands of long-tailed ducks concentrate in coastal Beaufort Sea lagoons to feed, molt, and stage prior to fall migration (Fischer and Larned 2004).
Figure 4.5.—Long-tailed duck breeding, molting, and staging habitats in the Sale Area.

Source: (Smith et al. 2017)
iii. Loons

Of the loons that nest on the North Slope, yellow-billed loons are the least abundant while Pacific loons are the most abundant. Both yellow-billed and red-throated loons spend most of their lives at sea and use lakes and rivers in the Sale Area during and after breeding. Loons are relatively large-bodied, long-lived birds with a low annual reproductive output, such that population stability depends upon high annual adult survival (Barr et al. 2000; USFWS 2014). On the coastal plain, modeled population trends indicate that Pacific loons appear stable, while red-throated loons are declining and yellow-billed loons are increasing. Red-throated loon modeled trends indicate this population is declining at an annual rate of 3.4 percent per year (Amundson et al. 2019), in contrast to the stable population trend reported by Wilson et al. (2018) for this survey.

Yellow-billed loons likely feed on both marine and freshwater fish during nesting, such as ninespine sticklebacks and least cisco. They use lead systems, preferring small open-water leads over extensive areas of open water, during spring migration and concentrate in early-melt areas at river deltas (North 1994). Their coastal plain breeding population shows a long-term increasing trend of about 1 percent per year; this population has remained stable to decreasing at a non-significant rate of about 4 percent per year over the past 10 years, primarily due to low abundance during the 2017 survey (Wilson, H. M. et al. 2018). After conducting a comprehensive status review of the yellow-billed loon (USFWS 2014), USFWS determined that protecting yellow-billed loons under the Endangered Species Act was not warranted (79 FR 59195). In the Sale Area, yellow-billed loons use relatively large deep lakes for nesting and brood-rearing (Huryn and Hobbie 2012), including Toolik Lake and a few other large lakes south of their coastal plain distribution as shown in Figure 4.6.

iv. Seabirds

Seabirds nesting in the Sale Area include jaegers, terns, and gulls (Huryn and Hobbie 2012). Based on survey route data, long-tailed jaegers were the most abundant followed by glaucous gulls and arctic terns (Table 4.5). Gulls and terns nest near water, while long-tailed jaegers nest in tussock tundra and alpine heath habitats (Huryn and Hobbie 2012).

Glaucous gulls arrive on the North Slope in early May. Glaucous gulls in the Sale Area are likely breeding birds that predate and scavenge bird eggs and chicks, small mammals, fish, invertebrates, berries, carrion, and garbage. They also scavenge on caribou gut piles discarded by hunters and road-killed ground squirrels along the Dalton Highway (Huryn and Hobbie 2012). Gulls nesting in the foothills nest individually on river bars and small islands and peninsulas in lakes and ponds (Weiser and Gilchrist 2020; Huryn and Hobbie 2012). Common ravens and jaegers predate glaucous gull eggs and chicks. Unlike areas in arctic Canada where glaucous gull populations have declined, the breeding population on the coastal plain has increased at a rate of nearly 10 percent per year over the past 10 years (Wilson, H. M. et al. 2018); with increasing trends closer to the Chukchi and Beaufort sea coasts, and stable trends away from the coasts toward the foothills (Amundson et al. 2019).
Figure 4.6.—Yellow-billed loon breeding and staging habitats in the Sale Area.

Source: (Smith et al. 2017)
Long-tailed jaegers are the smallest of the three jaegers (long-tailed, parasitic *Stercorarius parasiticus*, and pomarine *S. pomarinus*) occurring on the North Slope. They arrive in May from their at sea habitats where they spend most of their lives. Their breeding season diet consist primarily of lemmings and voles. While parasitic and pomarine jaegers are regular visitors, long-tailed jaegers are more likely to nest in the foothills. Long-tailed jaeger nest sites are often on low ridges or slopes, in more elevated and drier sites than used by parasitic jaegers. Long-tailed jaeger populations are considered stable overall with no current evidence of any changes in abundance or distribution. Breeding populations fluctuate, and breeding attempts and success are linked to lemming abundance; making long-tailed jaegers vulnerable to any disruption of lemming cycles caused by climate change (Huryn and Hobbie 2012; ADF&G 2015b; Wiley and Lee 2020). On the coastal plain, jaeger breeding populations are considered stable (Wilson, H. M. et al. 2018; Amundson et al. 2019).

v. Shorebirds

North Slope waterbirds are dominated in terms of both abundance and diversity by shorebirds (Bart et al. 2012). Millions of shorebirds nest on the coastal plain, and many use coastal areas north of the Sale Area after breeding for staging prior to their fall migrations (Taylor, A. R. et al. 2011; Taylor, A. R. et al. 2010). Shorebirds use streams, rivers, wetlands, ponds, and lakes to forage for invertebrates. Shorebirds arrive in the foothills in May and June and nest in habitats that are snow-free early in the season (Huryn and Hobbie 2012). For the seven shorebird species recorded on recent breeding bird survey routes, Wilson’s snipe were the most abundant, followed by American golden-plover, whimbrel, red-necked phalarope, and semipalmated sandpipers (Table 4.5). Conservation status for American golden-plovers, semipalmated sandpipers, and whimbrel in Alaska are rated high concern (ASG 2019). Potential threats to the breeding habitats of these shorebirds in Alaska include climate-related changes in habitat that include increased cover and height of shrubs and changes in phenology (ASG 2019).

American golden-plovers are found in tundra habitats in the foothills and mountainous ecoregions of the North Slope (ASG 2019). They nest on dry heaths of well-drained ridges and kames next to moist tussock and wetland habitats (Huryn and Hobbie 2012), and nest cups may be repeatedly reused (Johnson, O. W. et al. 2020). Their diet consists of adult and larval insects such as grasshoppers, beetles, grubs, cutworms, wireworms; earthworms; small mollusks and crustaceans; spiders; crowberries *Empetrum* spp. and bog blueberries. Males return to and defend specific breeding territories that are used year after year and range in size from 25 to 125 acres. Breeding birds forage on various types of tundra ranging from large expanses of low vegetation only a few centimeters tall (as on well-drained slopes) to wetter mosaics of low shrubs and grasses interspersed with openings. After young hatch, families move to moist shrub-sedge/grass tundra for feeding and cover. American golden-plovers spend winters on the pampas of Argentina and the campos of Uruguay (Johnson, O. W. et al. 2020).

Semipalmated sandpipers are one of the most abundant shorebirds nesting throughout the arctic coastal plain and foothills, with higher densities nesting in the coastal plain. Three breeding populations are recognized across the North American Arctic in Alaska, western Canada, and eastern Canada. They are an estimated 1.45 million birds on Alaska’s North Slope and this population is considered stable (ASG 2019). An estimated 8,700 semipalmated sandpipers may nest in the foothills (Bart et al. 2012). Males establish breeding territories, normally the same as used in the previous year, often reusing the previous year's nest cup. Nest locations are generally near ponds, as well as along the sides or tops of small hummocks or ridges. Nests may be located under, small shrubs or in a clump of sedges in damp low areas. In Alaska, most food items in June were midge larvae (60 percent), followed by crane fly larvae (15 percent), spiders (15 percent), and adult and larval beetles (10 percent). Adult insects were taken more often in July. Adult birds migrate
earlier than juveniles in fall, leading to two distinct migration peaks between age classes. Adult migration peaks in late July to mid-August, while juvenile (young of the year) migration peaks in late August to mid-September. Semipalmated sandpipers winter along the northern and central coasts of South America (Hicklin and Gratto-Trevor 2020).

**Whimbrel** are found in tundra habitats in the foothills and mountainous ecoregions of the North Slope (ASG 2019). North American subspecies, *Numenius phaeopus hudsonicus*, comprises two disjunct breeding populations, in subarctic tundra and alpine areas. Whimbrels nest in loose aggregations in open habitats that vary from wet lowlands to dry uplands (Skeel and Mallory 2020). They are most abundant in open tussock-tundra valleys in the foothills, where they nest on well-drained ridges (Huryn and Hobbie 2012). Upon arrival to their breeding grounds, whimbrel forage on last summers’ berries, including crowberry, bog blueberry, low-bush cranberry, and bearberry *Arctostaphylos* spp., switching to insects as these become abundant. This long-lived wader is monogamous and territorial, with mates sharing incubation of four eggs. Adults leave breeding areas before juveniles passing through coastal habitats in July and August, with young-of-the-year following in September (Skeel and Mallory 2020). Whimbrels winter along the southern coast of the United States to Brazil (Huryn and Hobbie 2012).

### b. Landbirds

Landbirds potentially occurring within the Sale Area include raptors, owls, ptarmigan, and passerines (perching birds). Most landbirds in the Sale Area are migratory although gyrfalcons, snowy owls, and common ravens may remain on the coastal plain through winter when prey is abundant, and ptarmigan remain year-round (Johnson, S. R. and Herter 1989). Most landbirds have altricial young that require weeks to months of parental care and feeding at the nest site. The exception is ptarmigan, which have precocial young that are capable of leaving the nest and foraging for themselves within hours to days after hatching. The current warming trend in the arctic has shifted the transition from winter to summer to weeks earlier over the last century and some passerines have responded by arriving an average of 6 days earlier from 1964 to 2013 (Ward et al. 2016) and initiating clutches from 4 to 7 days earlier from 2002 to 2011 (Liebezeit et al. 2014). Mean hatch dates for peregrine falcons nesting on cliffs along the Colville River overall occurred later; although mean hatch dates occurred earlier for territories that were occupied more frequently over the 24 year period from 1981 to 2011 (Swem and Matz 2018).

Ground-based surveys that cover both coastal plain and foothills locations indicate that a few landbirds also nest in high densities in the foothills including rock and willow ptarmigan, Savannah sparrow, and Lapland longspur (Bart et al. 2012).

#### i. Raptors

Raptors nest in high concentrations on river bluffs in the lower Colville River important bird area (Audubon 2013) along the northwest side of the Sale Area boundary (Figure 4.4). Golden eagles *Aquila chrysaetos* have been documented nesting west of the Sale Area on the largest cliffs associated with rivers in the southern foothills near the Brooks Range (Ritchie et al. 2003). Golden eagles are likely to nest in the Sale Area, and commonly hunt in the foothills for ground squirrels, caribou calves, foxes, and birds especially owls and ptarmigan. Northern harriers nest on the ground in the Sale Area in wet, shrubby tundra, where they prey on voles, lemmings, songbirds, and ptarmigan (Huryn and Hobbie 2012). An average of 275 golden eagles were recorded during coastal plain surveys during 2008 to 2017; with a nonsignificant declining rate of about 0.4 percent per year (Wilson, H. M. et al. 2018). Raptors observed along the breeding bird survey routes included northern harrier, rough-legged hawk, and merlin (Table 4.5).
Arctic peregrine falcons feed almost entirely on birds including shorebirds, passerines, and ducks (White et al. 2020). They nest in the Sale Area primarily on bluffs along the Colville River, the Sagavanirktok River, and other drainages, but also have been found nesting on bluffs at lakes and along streams (Ritchie et al. 2003; BLM 2008a). Arctic peregrine falcons occur on the North Slope from late April through September. Nesting begins by mid-May, and young birds fledge from late July to late August. Immature peregrines move northward toward the Beaufort Sea coast during mid to late August through mid-September (Johnson, S. R. and Herter 1989), where they forage on molting long-tailed ducks and staging shorebirds. Peregrine falcons generally leave the North Slope by late September (BLM 2008b) and spend winters in Central and South America (White et al. 2020). Approximately 250 pairs of arctic peregrine falcons nest in Alaska each year (BLM 2008b). Long-term monitoring indicates the population nesting on the Colville River stabilized at an average of 57.4 pairs, although productivity (number of young per pair) has continued to decline from 1981 to 2011 (Swem and Matz 2018).

Gyrfalcons feed predominately on birds and specialize on ptarmigan, but will take all sizes of birds, from passerines to geese, as well as rodents and hares (Booms et al. 2020). They nest on cliffs and will use artificial structures or stick nests built by other raptors and ravens (Booms et al. 2020). Habitat modeling predicts that gyrfalcon nests occur closest to the coast within the ANWR and predicts greater occurrence of breeding pairs on the North Slope east of the Sagavanirktok River (Booms et al. 2010). Gyrfalcons may remain year-round within their breeding habitat depending on prey availability and both reproduction and winter movements are strongly tied to food availability. An estimated 366 to 726 pairs of gyrfalcons nest in Alaska, with 90 known pairs nesting along rivers with suitable cliffs on the northern slope of the Brooks Range (Booms et al. 2010; Booms et al. 2020). The Colville River and adjacent drainages support about 70 to 80 gyrfalcon territories (Ritchie et al. 2003). Similar to peregrine falcons, immature gyrfalcons move northward toward the Beaufort Sea coast during August and September (Johnson, S. R. and Herter 1989), where they forage on molting long-tailed ducks and staging shorebirds.

Rough-legged hawks arrive on the North Slope in early May to construct stick nests on cliffs and bluffs along streams and rivers. They are the most abundant and widespread cliff-nesting raptor in NPR-A with 109 pairs found in 1999 (Ritchie et al. 2003). The North American population is estimated at 310,000 birds (Rosenberg et al. 2016). Most nests on the NPR-A were constructed on cliffs in the southern foothills with a few nests scattered in the northern foothills. Shale bluffs and rock cliffs were most often used for nest sites, but scree and talus slopes, and mud banks were also used (Ritchie et al. 2003). Rough-legged hawks feed on lemmings, voles, and ground squirrels, but also take shorebirds and ptarmigan. Rough-legged hawks migrate to winter habitats in southern Canada and the northern contiguous United States in late September (Huryn and Hobbie 2012).

**ii. Owls**

Short-eared and snowy owls nest on the ground in arctic tundra. North American populations for these owls are considered to have declined by over 60 percent between 1970 to 2014 based on breeding bird survey route data (Rosenberg et al. 2016). Both owls depend on abundant small mammal prey and nesting success fluctuates with abundance of their prey.

Snowy owls use a wide range of prey, eat carrion, and may scavenge polar bear kills. Snowy owls may winter in arctic terrestrial and marine environments when sufficient food is available. They often winter near villages, open leads, open water within the pack ice and polynyas where they hunt lemmings, hares, ptarmigan, seabirds, seaducks, and may scavenge food killed by other predators (Holt et al. 2020). Because snowy owls are nomadic and because they only breed when adequate prey resources are available, population size and trend are difficult to measure. The nesting population near Utqiaġvik is believed to have declined over the past 22 years (Holt et al. 2020). The
North American population of snowy owls is estimated at less than 30,000 birds (Rosenberg et al. 2016). Because of their intermittent breeding and because non-breeding birds may aggregate, both long-term and 10-year average indices based on annual aerial breeding pair surveys show high variability (Wilson, H. M. et al. 2018). Their coastal plain breeding population shows a long-term non-significant increasing trend of about 1 percent per year; with a stable to decreasing non-significant trend rate of about 13 percent per year over the past 10 years, and low abundance during both the 2016 and 2017 surveys (Wilson, H. M. et al. 2018).

**Short-eared owls** nest throughout Alaska, arriving on the North Slope in May. They use open tundra habitats where they hunt day and night on voles, lemmings and passerines. They nest in shrubby or wet sedge tundra (Huryn and Hobbie 2012), typically on elevated patches of vegetation (Wiggins et al. 2020). The North American population is estimated as 660,000 (Rosenberg et al. 2016). An average of 550 short-eared owls were recorded during coastal plain surveys during 2008 to 2017; with a nonsignificant declining rate of about 1.2 percent per year (Wilson, H. M. et al. 2018). Short-eared owls are partial migrants, although those breeding in the northern part of their ranges may be highly migratory. Non-breeding birds may be found from southern Canada to southern Baja California (Wiggins et al. 2020).

**iii. Ptarmigan**

Both willow and rock ptarmigan occur in the Sale Area (Table 4.5). Willow ptarmigan are widely distributed on the North Slope, but rock ptarmigan are found primarily in the foothills and mountains (Huryn and Hobbie 2012). Ptarmigan feed primarily on vegetation, with dwarf birch and willow buds and catkins important winter foods, and berries important in spring and fall. Both species lay clutches of 6 to 10 eggs in early June, likely live for less than 8 or 9 years, and change coloration through molting to match seasonal changes in the color of their environment. Plumage turns all white during winter, mottled brown during summer, with a warmer brown or gray during fall. Males establish and defend breeding territories. Chicks are precocial, leaving the nest and feeding themselves the day they hatch. Both willow ptarmigan parents attend and defend their brood until October, while only the female rock ptarmigan remains with her brood. Although their breeding ranges overlap, willow ptarmigan generally use wetter habitats with more shrubs, while rock ptarmigan use dry, rocky areas. During winter ptarmigan aggregate into flocks of dozens to hundreds of birds (Hannon et al. 2020; Montgomerie and Holder 2020).

Although ptarmigan are not considered migratory birds, both willow and rock ptarmigan make seasonal movements between breeding and winter ranges (Hannon et al. 2020; Montgomerie and Holder 2020). Juvenile and adult male rock ptarmigan may remain on or very near the breeding grounds throughout the year, but juvenile and adult female rock ptarmigan disperse up to 100 miles from breeding grounds to wintering habitats (Merizon and Carroll 2019). Willow ptarmigan hens nesting or reared on the North Slope near the Sale Area may move up to 100 miles south in late fall, wintering on the south side of the Brooks Range in the low hills and wooded valleys north of the Yukon River. Male willow ptarmigan from the North Slope also tend to move south during October and November, but do not move as far south as the hens. Northward movements toward breeding grounds begin in February, peak in April, and are completed by mid-May (ADF&G 2020h). Ground-based surveys estimated 163,500 willow ptarmigan and 44,000 rock ptarmigan breeding in the foothills, which represented 18 percent, and 36 percent of the North Slope breeding populations, respectively (Bart et al. 2012).

**iv. Passerines**

Passerines, also known as perching birds, are a diverse group of landbirds composed primarily of songbirds. Passerines are the most abundant birds breeding in the Sale Area: 74 percent of Happy Valley route birds and 71 percent of Galbraith Lake route birds. Of the 22 passerine species
recorded in the Sale Area, an average of 12 species and 231 individuals occur along the Happy Valley route, and 9 species and 217 individuals occur along the Galbraith Lake route each year. Of the 22 passerine species in the Sale Area, 18 are considered species of greatest conservation need (Table 4.5). Hoary redpolls were distinguished from common redpolls in 2 of 10 years on the Happy Valley route, otherwise counts of hoary and common redpolls are combined (Pardieck et al. 2019).

Sparrows are the most numerous passerines in the Sale Area. Four of the five species of sparrows nesting on the North Slope occur in the Sale Area: Savannah sparrows are the most abundant followed by American tree, white-crowned, and fox sparrows (Table 4.5). Arriving on the North Slope in May, sparrows nest on the ground concealed by overhanging vegetation or in low shrubs. Savannah sparrows are the most abundant passerine in the foothills, where they nest on the ground in riparian thickets and shrubby tussock tundra. American tree sparrows may be locally abundant in riparian willow thickets and shrubby tussock tundra in the foothills, where they nest on the ground on mossy hummocks or in willows. White-crowned sparrows are common in riparian willow thickets, where they nest on the ground in dwarf birch low shrub habitats or in shrubs. Fox sparrows use dense willow thickets along foothill streams, where they nest in shrubs or on the ground. Clutches of three to six eggs are incubated by the female. Sparrows forage on seeds, berries, and insects. Most sparrows leave for wintering habitats by late August, although some may remain until September (Huryn and Hobbie 2012). North American populations of these sparrows are declining, some with declines of 18 to 53 percent since the 1970s (ADF&G 2015b; Rosenberg et al. 2016). Effects of climate change in the foothills are expected to increase shrub habitats which may benefit sparrows that rely on shrub habitats (Martin et al. 2009).

Four passerines in the Sale Area are considered species of concern: bank swallow, horned lark, Smith’s longspur, and Wilson’s warbler (Table 4.5). Bank swallows, horned larks, and Wilson’s warblers nest throughout much of Alaska and have relatively large populations in North America of 7.7, 97, and 76 million, respectively (Rosenberg et al. 2016). Horned larks are relatively common on heaths in the foothills where they feed on seeds and insects. They arrive on the North Slope in early May and nest are constructed on the ground in barren, stony habitats (Huryn and Hobbie 2012). Horned larks prefer bare ground and short vegetation. The subspecies that nests in Alaska and the Yukon (Eremophila alpestris arcticola), winters in British Columbia, northern California to Wyoming (Beason 2020). The breeding distribution of Smith’s longspur in Alaska is limited to uplands of southeastern central Alaska and the Brooks Range and northern foothills which coincides with the Sale Area (Briskie 2020). They are common in the foothills, especially in the Atigun, and Sagavanirktok River valleys as far north as Sagwon Bluffs (Huryn and Hobbie 2012). They arrive in May and nest on the ground in sedge and tussock tundra. In late July to mid-august they migrate through the Great Plains and Prairie Provinces to winter in the southern Great Plains (Briskie 2020).

Common ravens are attracted to settlements and make use of man-made features for nesting (Powell and Backensto 2009; Backensto 2010). Oil and gas infrastructure and access to supplemental nutrition through access to human foods, especially during winter, have extended their breeding and winter range northward on the coastal plain and has led to concerns that ravens would depress tundra nesting shorebirds and passerine populations through predation. The Kuparuk and Prudhoe Bay oil fields supported 18 to 25 breeding pairs annually during 2004 to 2007 (Backensto 2010). Some common ravens overwinter on the coastal plain and counts indicate that the overwintering population increased at a rate of about 10 percent per year from 1987 to 2012, the last year on record for the count (Audubon 2018).
3. Terrestrial Mammals

The most abundant, although least conspicuous mammals in the Sale Area are voles Microtus spp. and lemmings Dicrostonyx groenlandicus and Lemmus trimucronatus. These tiny herbivores go through periodic abundance cycles that are most likely related to vegetation damage caused by winter overgrazing of sedges and grasses. These small mammals are important prey for raptors, owls, gulls, jaegers, foxes, and weasels. Other common mammals include arctic ground squirrels Urocitellus parryii and Alaska marmots Marmota broweri that are prey for raptors, wolves, and bears (Huryn and Hobbie 2012). Key terrestrial mammals in the Sale Area that provide subsistence resources and that may be susceptible to cumulative impacts from oil and gas exploration and development include: caribou Rangifer tarandus, moose Alces alces, muskox Ovibos moschatus, Dall sheep Ovis dalli dalli, brown bear Ursus arctos, wolf Canis lupus, and red fox Vulpes vulpes (NRC 2003; Trammell et al. 2015). Inupiat names are: caribou – tutu, moose – tuttuvak, muskox – umiŋmak, Dall sheep – imnaaq, brown bear – aklaq, wolf – amaŋq, and red fox – kayuqtuq.

Terrestrial mammals on the North Slope have been influenced by climate warming that has allowed range expansions, induced changes in forage quantity and quality, increased competition for forage resources, and changed vegetation structure (Gallant, D. et al. 2012; Huryn and Hobbie 2012; Tape et al. 2016; Cuyler et al. 2020).

a. Caribou

Caribou from the Western Arctic (WAH), Teshekpuk (TCH), and Central Arctic (CAH) caribou herds range seasonally across the foothills within the Sale Area. Portions of the Sale Area are used primarily as summer range by caribou from these three herds and as winter range by TCH and CAH caribou. Calving ranges for these caribou herds are located primarily outside of the Sale Area.

Caribou herds are defined by their calving ranges, although annual herd ranges are extensive and often overlap. Caribou cows calve annually and show fidelity to their natal calving ranges, with relatively low emigration/immigration rates ranging from 0.9 to 8.7 percent per year (Person et al. 2007; Prichard et al. 2020). The WAH generally calves in the Utukok Hills (Dau, J. 2015), the TCH calves around Teshekpuk Lake (Parrett 2015), and the CAH calves between the Colville and Canning rivers (Lenart 2015b). Typically, most pregnant cows reach the calving grounds by late May, with peak calving in early June. These herds mix on summer and winter ranges. After calving caribou gather into large post-calving aggregations to avoid predators and parasitic insects. Caribou move to windblown locations such as hilltops, river bars, and coastal areas with sparse vegetation that provide some relief from dense swarms of mosquitoes. Caribou movement between and within seasonal ranges are triggered by changing weather conditions, parasitic insect harassment, and availability of adequate forage (Harper and McCarthy 2015).

Herd sizes fluctuate naturally, with arctic herds historically undergoing well-defined and largely synchronous 30- to 40-year periods of abundance and scarcity potentially driven by continental-level climate change such as the Arctic Oscillation (Griffith et al. 2002; Gunn et al. 2009). Fluctuations are driven by weather conditions, habitat quality, disease, predation and other factors with declining periods characterized by low adult and calf survival and low reproduction rates and increasing periods characterized by high adult and calf survival and high reproduction rates (McFarland and Taras 2016; McFarland et al. 2017; WACHWG 2018). As arctic caribou herds increase in size, they expand their ranges creating more overlap and mixing during summer, migration, and winter with an increase in emigration of cows between herds that blurs distinctions and hampers population estimates (Mager et al. 2013; Harper and McCarthy 2015).
i. Western Arctic Caribou Herd

The WAH ranges over about 157,000 square miles in northwestern Alaska, from the Chukchi coast east to the Sagavanirktok River, and from the Beaufort Sea coast south to the Seward Peninsula and Nulato Hills (Dau, J. 2015). The western half of the Sale Area (Figure 4.7) is summer range for the WAH (WACHWG 2019). WAH caribou, predominantly cows, use this region primarily in late summer from the end of July to mid-September (Dau, J. 2015; Baltensperger and Joly 2019). The WAH is the largest of the arctic caribou herds although this herd has declined from a peak of 475,000 animals since 2003 (Figure 4.8). The most recent estimate indicates that the herd decreased between 2017 and 2019 (WACHWG 2020). There is no evidence that hunting, predation, environmental contaminants, range degradation, or disease are currently limiting the size of the WAH, although adult cow survival and yearling recruitment both show long-term negative trends. Icing events may cause high mortality in some years and predators appear to have had a greater influence on WAH population dynamics since 2015, than during the previous 30 years of monitoring (Dau, J. 2015). Currently this herd is considered to be conservative declining (WACHWG 2020).
Figure 4.7.—Western Arctic caribou herd seasonal ranges in the Sale Area.

Source: (ABR 2019)
The TCH ranges over 56,000 square miles in northwestern Alaska, from the Nulato Hills in the south, the ANWR to the east, and the Chukchi Sea to the west (Parrett 2015). Calving occurs between May to late June near Teshekpuk Lake. Emigration of TCH cows to neighboring WAH and CAH calving areas occurs at a rate about 7 percent per year (Person et al. 2007), and more recently some WAH and CAH cows have calved with the TCH (Parrett 2015). The area between Teshekpuk Lake and the Beaufort Sea is used for mosquito-relief habitat from late June through early August, with most use during early July, followed by inland dispersal later in summer (Yokel et al. 2008; Wilson, R. R. et al. 2012; Parrett 2015). A substantial proportion of the TCH remain on the coastal plain through the winter with primary concentrations generally near Atqasuk and Wainwright, south of Teshekpuk Lake, and east of Anaktuvuk Pass (Person et al. 2007; Parrett 2015); although a portion of the herd winters in the Brooks Range, similar to the CAH (Figure 4.9). TCH animals use the north central portion of the Sale Area as summer range, and the eastern half of the Sale Area as winter range (Figure 4.9). The Sale Area is crossed by TCH caribou wintering in the Brooks Range to move northward during spring migration from April 16 to May 31 and southward during fall migration from September 6 to November 30 (ABR 2017; ADF&G 1986c).

The TCH increased substantially after 1984, reaching a peak of nearly 70,000 caribou in 2008 (Figure 4.10). Reduced cow survival appears to have been a major contributor to population declines in 2011 and 2013, which was also characterized by low parturition and calf survival. Elevated late winter-spring yearling mortality may be due to increased predation (Parrett 2015). The increase in the 2015 count may indicate that the decline has stabilized, with increases in both cow survival and parturition rates (ADF&G 2016c) that likely contributed to the increased count in 2017 (Klimstra 2018).
Figure 4.9.—Teshekpuk caribou herd seasonal ranges in the Sale Area.

Source: (ABR 2019)
iii. Central Arctic Caribou Herd

The CAH ranges over 25,800 square miles from just west of the Colville River to the Canadian border to the south side of the Brooks Range. From June through mid-August, the CAH ranges across the coastal plain from Fish Creek eastward along the coast to the Canadian border (Lenart 2015b). CAH range within the oil-field region near Prudhoe Bay, the Dalton Highway and the Trans-Alaska Pipeline (NRC 2003; Nicholson et al. 2016). Cows begin spring migration during early May and fall migration in mid-September crossing through the Sale Area, primarily in the eastern half (Nicholson et al. 2016). Calving peaks in early June and is concentrated within two areas, between the Colville and Kuparuk rivers on the west side, and between the Sagavanirktok and Canning rivers on the east side of the Dalton Highway (Lenart 2015b). Caribou movements during summer are influenced by parasitic insect abundance. When temperatures are high and wind speeds are low, mosquito activity increases with peak abundance generally in early July. Caribou tend to concentrate along the coast during warm weather but move inland on cool and windy days (Lenart 2015b). In mid to late July CAH caribou begin to move south toward the Brooks Range. During shallow snow conditions CAH caribou may winter in the foothills or in deep snow conditions may continue south crossing though Atigun and Anaktuvuk passes to winter on the south side of the Brooks Range (Huryn and Hobbie 2012). CAH use the Sale Area for summer and winter range (Figure 4.11), as well as for spring and fall migration (Nicholson et al. 2016).
Figure 4.11.—Central Arctic caribou herd seasonal ranges in the Sale Area.
The CAH increased substantially after 1998, reaching a peak of nearly 70,000 animals in 2010 (Figure 4.12). This increasing population trend was attributed to high cow survival rates, high parturition rates and good fall calf recruitment during 1998 to 2010 (Lenart 2015b). A late spring in 2013 resulted in high adult and yearling cow mortality, which was reflected in the summer 2013 photo census (Lenart 2015b). The sharp decline after 2013 was primarily attributed to low adult cow survival but coincided with exceptionally low predicted forage nitrogen values in 2014 and 2015 (Johnson, H. E. et al. 2018). The CAH is currently considered stable (Curl 2020).

Figure 4.12.—Central Arctic caribou herd size and cow survival.

b. Moose

Moose were not observed on the North Slope prior to 1880, were considered scarce prior to the 1940s, and by the 1950s were common east of the Colville River (ADF&G 1986b). Moose expanded their range north of the continental divide after about 1860, coincident with climate warming that facilitated expansion and increased volume and height of riparian willows (Tape et al. 2016). In winter, moose are generally confined to riparian habitats along larger North Slope rivers, where they primarily browse on deciduous shrubs that extend above the snowpack. In summer, moose move into small tributaries and hills surrounding riparian habitats and may disperse into surrounding tundra where they forage on emergent vegetation, herbaceous plants, and the leaves and shoots of shrubs (ADF&G 1986a; Lenart 2018; Klimstra and Daggett 2020). Moose survey areas in Game Management Unit (GMU or Unit) 26A and 26B are focused on rivers that cross or border the Sale Area (Lenart 2018; Klimstra and Daggett 2020). Moose breed during late September and early October, with cows typically breeding at about 28 months. Cows give birth each spring to one or two calves, and moose generally do not live more than 16 years (ADF&G 2020f).
Moose numbers likely peaked in GMU 26 during the late 1980s at nearly 3,000 moose, then declined and remained at low numbers in the 1990s likely due to a combination of high adult mortality and poor calf survival. The decline appeared to be due to a combination of malnourishment, bacterial diseases that cause abortions and weak calves, predation, severe weather, and competition from snowshoe hares. Snowshoe hares also expanded their range on the North Slope and irrupted in the early 1990s, which may have caused additional stress to willows already over browsed by high moose numbers in the 1980s. Wolves and brown bears are important moose predators and were also relatively abundant during this period of declining moose numbers. During the early 2000s moose numbers slowly increased and peaked in the mid-2000s, stabilizing at lower levels by the end of the decade (Figure 4.13). The population in GMU 26 crashed to less than 300 moose in spring 2014 likely due to recruitment failure accompanied by high adult mortality (Lenart 2018; Klimstra and Daggett 2020).

**Figure 4.13.—Moose spring trend counts and percent short yearlings.**

**c. Muskoxen**

Muskoxen range across the coastal plain and foothills within the Sale Area from Teshekpuk Lake to the Canada border (Harper and McCarthy 2017). They disperse in small groups to coastal and riparian habitats during the spring and summer where they feed primarily on grasses and sedges, followed by shrubs and mosses (Arthur and Del Vecchio 2013). Muskoxen aggregate into herds of up to 75 animals and use windswept habitats for foraging because of their inability to efficiently dig through heavy snow cover (Klein et al. 1993; ADF&G 2016b). Wolves and brown bears prey on
muskox adults and calves. Muskox breed from late summer into fall and most calves are born between May 1 and May 15 (Arthur and Del Vecchio 2013).

Muskox populations throughout the arctic have gone through extreme changes in abundance, such that by the 1930s muskoxen had disappeared from Alaska (Arthur and Del Vecchio 2013, 2017; Lenart 2015c). Muskoxen that occur within and south of the Sale Area are descendants of animals that were reintroduced to northeastern Alaska between 1969 and 1970 (Lenart 2015c; ADF&G 2016b). By the mid-1990s, this reintroduced population appeared to be stable at around 700 animals in northeastern Alaska and Yukon, Canada (ADF&G 2012). Abundance of calves, yearlings, and adults began declining in GMU 26C in 1999 (Lenart 2015c). The decline in abundance was attributed primarily to depredation by brown bears, although pathogens were present that could reduce reproduction and survival, and heavy snow cover may have increased vulnerability to predation (Arthur and Del Vecchio 2017). This muskoxen population remained relatively stable at a reduced level of around 200 animals after 2004 (Figure 4.14), and is currently considered to be increasing at nearly 300 animals (Cuyler et al. 2020).

Figure 4.14.—Muskoxen population size and cow survival.

d. Dall Sheep

Dall sheep occur throughout the Brooks Range. Most Dall sheep habitat in the central and eastern Brooks Range occurs outside of the Sale Area within GAAR and ANWR, although several isolated patches of habitat and several mineral licks occur within the Sale Area. During summer when food is abundant Dall sheep consume a wide variety of plants. Their winter diet consists primarily of dry, frozen grass and sedge available where snow is blown from their winter range. Dall sheep use mineral licks during the spring and may travel many miles to consume minerals from these sites. Dall sheep rams may live for 16 years and ewes for 19 years. Lambs are born in late May or early
June. Ewes typically have their first lamb at age 3 or 4 years and thereafter produce a lamb each year on rugged cliffs on their spring ranges. The breeding season is late November and early December (ADF&G 2020d).

Dall sheep population index surveys for the central Brooks Range are flown within GAAR. The population was considered low during the early to mid-1970s; increasing between 1982 and 1984, stable from 1984 through 1987, and declining by 1996 when lamb recruitment was low after several winters of heavy snowfalls. The mean number of Dall sheep recorded during index counts in the central Brooks Range from 2002 to 2015 was about 1,300 sheep (Caikoski 2018a).

e. Brown Bears

Brown bears are widely distributed across the North Slope, with densities generally highest in the foothills, moderate in the Brooks Range, and lowest on the coastal plain (Carroll 2015; Lenart 2015a). Brown bears are omnivorous, and bears inhabiting the North Slope are generally considered to be primarily herbivorous supplementing their diet whenever possible with animals (Shideler and Hechtel 2000; Bentzen et al. 2014). Brown bears are opportunistic scavengers of ungulate carcasses and predators of arctic ground squirrels, caribou calves, muskoxen, microtine rodents, bird eggs and nestlings. Bears occur more frequently within riparian habitats along rivers and streams where their preferred forage plants and preferred arctic ground squirrel prey are likely to be found (Shideler and Hechtel 2000).

Brown bears are large, long-lived mammals with a relatively low reproductive potential. Female brown bears in the North Slope oil fields with access to human food on average reproduce earlier at 5.4 years old and more often with a 3.3-year reproductive interval compared to bears that feed on natural food that first reproduce at 7.4 years with a 4.8 year reproductive interval (Lenart 2015a). Brown bears on the North Slope enter their dens in late September to mid-November and emerge from March to May. The most frequently used denning sites include pingos, hillsides, and streambanks. Adult male bears are generally the last to enter and the first to emerge from dens, while pregnant females are generally the first to enter and females with cubs born in the den during January are the last to emerge. Presence of a predictable food source or garbage can delay den entrance (Shideler and Hechtel 2000).

The first population estimate for North Slope brown bears in the 1950s of 1,818 bears was based on extrapolations from resident, pilot, and big game guide observations. During the late 1960s to the 1970s, human activities on the North Slope led to an increase in Defense of Life and Property (DLP) brown bear kills. Concern over high numbers of DLP kills and guided bear hunt harvest led to restriction of brown bear harvest in the early 1970s. The North Slope brown bear population was estimated at 695 to 905 brown bears in 1981, which was revised to 1,015 to 1,340 bears in 1983 (Shideler and Hechtel 2000). The current population estimate for GMU 26 of 1,662 brown bears, with 147 bears using coastal plain habitats, is based on density estimates from the late 1990s to early 2000s (Carroll 2015; Lenart 2015a). Brown bear hunting regulations were liberalized in Unit 26B to maintain an estimated population of 200 to 320 bears, and bears identified as threatening or killing muskoxen were lethally removed (Lenart 2015a).

f. Furbearers

The most common furbearers in the Sale Area are weasels and red foxes. Wolves regularly occur and overwinter in the foothills. Wolverines *Gulo gulo* may rarely visit the North Slope, and northern river otters *Lontra canadensis* are uncommon residents associated with perennial spring streams that support overwintering Dolly Varden (Huryn and Hobbie 2012).
i. Wolves

Wolves are present throughout GMU 26 although generally less abundant compared to other parts of Alaska because their prey such as moose and Dall sheep occur at low abundance in most areas and large migratory caribou herds may only be seasonally available (Caikoski 2018b). Wolves are social and live in packs. They mate in late winter and pups are born in dens in May or June. Dens up to 3 m deep excavated in sandy, well-drained soil may be used for many years. After 8 to 10 weeks, pups are moved from the natal den to a series of rendezvous sites and by October, travel and hunt with the pack. Females first reproduce at 2 years, may continue producing for 10 or more years, and likely live less than 16 years (Huryn and Hobbie 2012).

Wolf numbers in Unit 26A have fluctuated widely since the turn of the nineteenth century. During the early 1900s, caribou, moose, and wolves were less abundant than they are today. Caribou and moose numbers increased after 1930, and by the 1940s wolves were abundant. Wolf numbers were greatly reduced by federal wolf control during the 1950s and by public aerial hunting during the 1960s. Following the ban on aerial wolf hunting in 1970 and land-and-shoot aircraft hunting of wolves in 1982, wolf populations increased, especially in the mountains and foothills of the Brooks Range. Wolves are less abundant on the coastal plain because of the seasonal scarcity of caribou, outbreaks of rabies, and their vulnerability to hunters in the open country (Caikoski 2018b; Klimstra 2020) A 2008 survey in the foothills between the Killik and Anaktuvuk rivers estimated about 78 wolves in 17 packs of two to eight wolves (Huryn and Hobbie 2012).

ii. Foxes

Both arctic foxes and red foxes may occur within the Sale Area, although arctic fox denning is limited to the coastal plain (Huryn and Hobbie 2012). Foxes are medium-sized carnivores that remain active during the winter. Their diets are similar, with preference for lemmings, voles, and bird eggs, although arctic foxes may rely less on lemmings than red foxes (Savory et al. 2014). To compensate for scarce terrestrial resources in winter, arctic foxes appear to be able to detect carcasses on sea ice up 25 miles away (Lai et al. 2015). Arctic foxes are better adapted to the cold and for travel over snow, and once they reach adulthood may live 5-times longer than red foxes (ADF&G 2016a; Gallant, D. et al. 2012). Red foxes have extended their ranges northward across most of the arctic coincident with increasing winter temperatures over the past decades (Gallant, D. et al. 2012; Carroll 2013). Red foxes are larger than arctic foxes, and where their ranges overlap red foxes dominate, displacing arctic foxes from den sites, and sometimes killing and consuming arctic fox adults and pups (Pamperin et al. 2006; Stickney et al. 2014). Both foxes opportunistically use supplemental nutrition and shelter within human settlements, which may be especially critical for survival during late winter and has apparently tipped the competitive advantage in favor of the red fox in the Prudhoe Bay region (Savory et al. 2014; Stickney et al. 2014).

Fox dens are widely recognized features of the arctic landscape. Usually located in mounds, hills, pingos, or ridges; a typical natural den site is excavated during late summer, has low snow cover, is above the water table, and has a deep active thaw layer, stable surface, and sandy soil (Burgess 2000). Within the oil fields foxes also use culverts, road berms, caribou crossing ramps, and the undersides of elevated buildings for den sites (Burgess 2000). In the Prudhoe Bay region, red foxes primarily use arctic fox dens, displacing arctic foxes from the den site and surrounding habitats (Stickney et al. 2014).

Increased physical contact between arctic and red foxes through fighting or predation increases the chances for rabies transmission and spread (Pamperin et al. 2006). Arctic foxes are considered the primary maintenance host for the rabies virus, although red foxes are more often diagnosed with rabies (Huettmann et al. 2017). Enzootic rabies is limited to northern and western coastal regions of Alaska, with cyclic increases in reported cases at 4 to 5-year intervals (Huettmann et al. 2017).
consistent with the distribution and pattern of periodic epizootics for arctic foxes (Pamperin et al. 2006).

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Chapter Five: Current and Projected Uses in the Sale Area

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Chapter Five: Current and Projected Uses in the Sale Area

This chapter considers and discusses the current and projected uses in the North Slope Foothills Areawide lease sales area (Sale Area), including uses and value of fish and wildlife as required by AS 38.05.035(g)(1)(B)(iv). The land and waters included within and near the Sale Area provide habitat for a variety of fish, birds, and terrestrial mammals, as described in Chapter Four. Fish and wildlife of the area provide the resource base for subsistence, hunting, and sport fishing.

The North Slope Borough (NSB) designates most lands within the Sale Area as conservation district, with lands adjacent to the Dalton Highway designated transportation corridor district and lands at the Toolik Field Station designated scientific research district (NSB 2005). The Sale Area includes all or portions of 46 North Slope Area Plan management units in the Brooks Foothills Region (64 percent), Central Slope Region (25 percent), and Dalton Corridor Region (11 percent of the Sale Area). Sale Area lands covered by the North Slope Area Plan are primarily designated for Resource Management (65 percent), followed by Habitat (14 percent), and then the combination of Habitat and Public Recreation-Dispersed with and without Transportation Corridor (19 percent; DNR 2020b).

The primary current industrial use of the Sale Area is oil and gas transportation (Trans-Alaska Pipeline System and Dalton Highway) with projected industrial use for oil and gas exploration, development, and transportation (natural gas pipeline) as discussed in Chapter Six. The following discussion provides an overview of the current and projected uses of the Sale Area.

A. Fish and Wildlife Uses and Value

The fish, birds, mammals, and plants of the Sale Area have been used by the residents of North Slope communities for thousands of years, forming the resource base for fishing, hunting, and gathering activities that are integral to the history, culture, food security, and economy of the area. The primary use of these resources is for subsistence, which broadly refers to any harvest of fish, wildlife, and wild plants for home use as well as noncommercial exchange or sharing (NSB 2016).

Management of fish and wildlife in the Sale Area can fall under the authority of either the state or federal government and may be subject to international treaties or agreements. Management authorities and types of harvest activities may overlap. Subsistence, hunting, trapping, and fishing on state lands are managed by the Alaska Department of Fish and Game (ADF&G). The ADF&G compiles and analyzes harvest and biological information, enabling the establishment of ecologically sound and population-based fishing, hunting, and trapping regulations. Subsistence hunting and fishing on federal lands and waters, including waters adjacent to federal lands, are managed by the Federal Subsistence Management Program (USDOI 2020).

Federal and state laws regulate subsistence use, access, and the trading of subsistence resources. On federal lands, the federal government is required by Title VIII of Alaska National Interest Lands Conservation Act (ANILCA) to provide a subsistence priority for rural Alaska residents unless the state provides this priority through its laws. AS 16.05.258 regulates subsistence use and allocation of fish and game. Subsistence uses in Alaska are regulated by the US Fish and Wildlife Service (USFWS), Office of Subsistence Management, and Alaska Boards of Fisheries and Game.

North Slope residents serve on several advisory committees such as the NSB, Fish and Game Management Committee and co-management organizations such as the Alaska Migratory Bird
Co-Management Council, which provide input to state and federal management agencies. The NSB Wildlife Department works with state and federal agencies to facilitate sustainable harvests and assure participation by NSB residents in management of fish and wildlife resources (NSB 2020). The foreseeable cumulative effects of post-disposal oil and gas exploration and development on fish and wildlife, including subsistence uses are discussed in Chapter Eight.

1. Local Subsistence

State and federal laws define subsistence use as customary and traditional uses of wild resources for food, clothing, fuel, transportation, construction, art, crafts, sharing, and customary trade (Fall 2018). Pursuant to AS 16.05.258, subsistence uses must be consistent with sustained yield and subsistence users must be provided reasonable opportunity to harvest fish and game resources first. Under Title 19 of the North Slope Borough Municipal Code (NSBMC), subsistence is defined as “an activity performed in support of the basic beliefs and nutritional needs of the residents of the borough and includes hunting, whaling, fishing, trapping, camping, food gathering, and other traditional and cultural activities” (NSBMC 19.20.020(67)). ANILCA defines subsistence usage as “the customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade” (16 U.S.C. § 3113).

North Slope residents continue to practice traditional subsistence lifestyles, relying on both marine and terrestrial resources. The importance of harvest activities to the spiritual and cultural wellbeing of the Iñupiat people, as well as the importance of subsistence resources for sustenance and materials, are described in detail in the North Slope Borough Comprehensive Plan (NSB 2018). Subsistence activities occur year-round, with coastal communities more dependent on marine mammals and other coastal resources than inland communities that primarily rely on caribou. Although Utqiagvik residents may use the Colville River border of the Sale Area for subsistence hunting or fishing, Nuiqsut and Anaktuvuk Pass are the primary communities that use the Sale Area for subsistence (SRBA 2010; Brown et al. 2016). Harvest seasons for subsistence resources harvested within or near the Sale Area by Nuiqsut and/or Anaktuvuk Pass are listed in Table 5.1.

Table 5.1.—Subsistence harvest timing for Nuiqsut and/or Anaktuvuk Pass.

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<th>Resource</th>
<th>Jan</th>
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<tr>
<td>Brown bear</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Dall sheep</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Freshwater fish</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Small mammals</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Furbearers</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Waterfowl</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Successful hunts require knowing both when and where to locate and safely harvest subsistence resources. Most harvest activities tend to be concentrated near communities, along rivers, and along the coastline as accessibility is an important factor (NSB 2016). The combined harvests for Utqiagvik, Nuiqsut, and Anaktuvuk Pass are dominated by marine mammals – primarily bowhead whales, followed by land mammals – primarily caribou, and non-salmon fish – primarily whitefishes and Dolly Varden (Figure 5.1). Subsistence harvest areas occur throughout the North Slope. In the Sale Area, use areas for Utqiagvik and Nuiqsut occur along the Colville River near Umiat, and the lower Chandler, and Anaktuvuk rivers (SRBA 2010). Based on search and harvest areas in Brown et al. (2016), the Sale Area is used to search for and harvest caribou, moose, small mammals, non-salmon fish, and vegetation by Nuiqsut and caribou, small mammals, non-salmon fish, and ducks by Anaktuvuk Pass.

Wild foods provide 259 percent of daily protein requirements, and 36 percent of daily caloric requirements in the Arctic. Harvest of wild foods plays a major role in supporting food security in Alaska, where the primary source of local foods is subsistence harvest (Fall and Kostick 2018). Although most Utqiagvik (91 percent), Nuiqsut (90 percent) and Anaktuvuk Pass (81 percent)
households reported high and marginal food security in 2014 (Brown et al. 2016), climate change and related changes in environmental conditions are viewed as a threat to subsistence harvests and food security. The warming climate is viewed as affecting uses through reduced populations, shifting migration patterns, increasingly difficult and unpredictable travel conditions, problems using traditional gear and harvest methods associated with ice (traps and nets deployed under ice), and food processing and storage challenges (Fall and Kostick 2018). The per capita harvest of subsistence foods shows an increasing trend over time since the 1980s (Figure 5.2), while populations in these communities have also increased (Brown et al. 2016). Increasing trends in subsistence harvest and use by these communities are expected to continue.

Harvest activities generally require travel to seasonal hunting and fishing camps and harvest areas. Boats, motors, all-terrain vehicles, fuel, guns, ammunition, and gear are necessary and must be purchased. Subsistence cost per household within communities near the Sale Area are substantial as shown in Table 5.2. In summer, boats are primary mode of transportation to the Sale Area from Nuiqsut, while all-terrain vehicles are the primarily most of transportation from Anaktuvuk Pass to hunting and fishing camps in the Sale Area. In winter, snowmachines are the primary transportation to hunting and fishing camps. Although harvest estimates are not available for Anaktuvuk Pass for 2015 and 2018, in general Utqiaġvik harvested on average 4 to 6 times more caribou than Anaktuvuk Pass or Nuiqsut. Caribou harvest per household for Anaktuvuk Pass, however, averaged twice that of Nuiqsut and nearly triple that of Utqiaġvik (Figure 5.3).

### Table 5.2.—Average household cost of subsistence activities 2010 and 2015.

<table>
<thead>
<tr>
<th>Village Subsistence Costs</th>
<th>Average Household Costs</th>
<th>Number Surveyed</th>
<th>Average Household Costs</th>
<th>Number Surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utqiaġvik</td>
<td>$3,762</td>
<td>$5,312</td>
<td>$2,554,319</td>
<td>$1,721,262</td>
</tr>
<tr>
<td>Nuiqsut</td>
<td>$7,135</td>
<td>$6,144</td>
<td>$492,366</td>
<td>$393,200</td>
</tr>
<tr>
<td>Anaktuvuk Pass</td>
<td>$3,175</td>
<td>$6,435</td>
<td>$165,119</td>
<td>$379,650</td>
</tr>
</tbody>
</table>

Source: (NSB 2016)
Figure 5.2.—Per capita harvests in edible pounds, Utqiagvik, Nuiqsut, and Anaktuvuk Pass.
Chapter Five: Current and Projected Uses in the Sale Area

NORTH SLOPE FOOTHILLS AREAWIDE OIL AND GAS LEASE SALES | Final Finding of the Director

Source: (Person et al. 2019)

Figure 5.3.—Recent caribou harvests for Utqiاغvik, Nuiqsut, and Kaktovik.

a. Utqiاغvik

About 89 percent of Utqiاغvik households used subsistence harvested resources in 2014, the most current year of study, averaging about 1,214 pounds per household or 362 pounds per person based on a sample of 259 surveyed households, representing 16 percent of eligible households. The top 10 most commonly used resources for households were: caribou 70.3 percent, bowhead whale 69.9 percent, broad whitefish 53.7 percent, bearded seal 43.6 percent, white-fronted goose 39.4 percent, salmonberry 37.1 percent, arctic cisco 36.3 percent, walrus 30.5 percent, sockeye salmon 29.3 percent and arctic grayling 27.0 percent (Brown et al. 2016).

Harvest by usable weight in 2014 was dominated by marine mammals at 53 percent, followed by land mammals at 31 percent, non-salmon fish at 10 percent, salmon at 3 percent, and birds and eggs at 3 percent (Figure 5.4). Harvest for the top 10 resources by species in 2014 was primarily caribou at 31 percent (Table 5.3).
Chapter Five: Current and Projected Uses in the Sale Area

Figure 5.4.—Utqiagvik total community harvest in edible pounds, 1987 to 2014.

Table 5.3.—Top resource harvest in usable weight per person, Utqiagvik 2014.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Usable Weight per capita (pounds)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caribou</td>
<td>110.6</td>
<td>31%</td>
</tr>
<tr>
<td>Bowhead whale</td>
<td>102.8</td>
<td>29%</td>
</tr>
<tr>
<td>Bearded seal</td>
<td>57.6</td>
<td>16%</td>
</tr>
<tr>
<td>Broad whitefish</td>
<td>26.5</td>
<td>7%</td>
</tr>
<tr>
<td>Walrus</td>
<td>19.5</td>
<td>5%</td>
</tr>
<tr>
<td>White-fronted goose</td>
<td>5.6</td>
<td>2%</td>
</tr>
<tr>
<td>Ringed seal</td>
<td>4.6</td>
<td>1%</td>
</tr>
<tr>
<td>Beluga whale</td>
<td>4.6</td>
<td>1%</td>
</tr>
<tr>
<td>Chum salmon</td>
<td>4.6</td>
<td>1%</td>
</tr>
<tr>
<td>Sockeye salmon</td>
<td>3.5</td>
<td>1%</td>
</tr>
<tr>
<td>All other resources</td>
<td>22.0</td>
<td>6%</td>
</tr>
</tbody>
</table>

Source: (Brown et al. 2016)
Note: top 10 resources, the “all other resources” category is all other resources that contributed less than 1% of the total harvest.
b. Nuiqsut

All Nuiqsut households used, and 90 percent successfully harvested, subsistence foods in 2014, averaging about 3,444 pounds per household or 896 pounds per person based on a sample of 58 surveyed households, representing 54 percent of eligible households. The top 10 most commonly used resources for households were: bowhead whale 93.1 percent, caribou 89.7 percent, arctic cisco 82.8 percent, white-fronted goose 74.1 percent, broad whitefish 72.4 percent, bearded seal 67.2 percent, cloudberry 62.1 percent, ringed seal 51.7 percent, moose 43.1 percent, and blueberry 39.7 percent.

Harvest by usable weight in 2014 was dominated by marine mammals at 46 percent, followed by land mammals at 29 percent, non-salmon fish at 23 percent, salmon at 1 percent, and birds and eggs at 1 percent (Figure 5.5). Harvest for the top 10 resources by species in 2014 was primarily bowhead whale at 40 percent (Table 5.4). Although annual harvests are highly variable and are influenced by the success of the bowhead whale harvest, in general harvest per capita shows an increasing trend from 1985 to 2014 (Figure 5.2).

Source: (Brown et al. 2016)

Figure 5.5.—Nuiqsut total community harvest in edible pounds, 1985 to 2014.
Table 5.4.—Top resource harvest in usable weight per person, Nuiqsut 2014.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Usable Weight per capita (pounds)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowhead whale</td>
<td>356.6</td>
<td>40%</td>
</tr>
<tr>
<td>Caribou</td>
<td>253.3</td>
<td>28%</td>
</tr>
<tr>
<td>Broad whitefish</td>
<td>88.2</td>
<td>10%</td>
</tr>
<tr>
<td>Arctic cisco</td>
<td>78.0</td>
<td>9%</td>
</tr>
<tr>
<td>Bearded seal</td>
<td>33.3</td>
<td>4%</td>
</tr>
<tr>
<td>Least cisco</td>
<td>22.5</td>
<td>2%</td>
</tr>
<tr>
<td>Ringed seal</td>
<td>14.8</td>
<td>1%</td>
</tr>
<tr>
<td>Chum salmon</td>
<td>8.4</td>
<td>1%</td>
</tr>
<tr>
<td>Moose</td>
<td>7.2</td>
<td>1%</td>
</tr>
<tr>
<td>White-fronted goose</td>
<td>7.0</td>
<td>1%</td>
</tr>
<tr>
<td>All other resources</td>
<td>26.5</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: (Brown et al. 2016)
Note: top 10 resources, the “all other resources” category is all other resources that contributed less than 1% of the total harvest.

c. Anaktuvuk Pass

Most Anaktuvuk Pass households used, and 89 percent successfully harvested subsistence foods in 2014, averaging about 1,255 pounds per household or 391 pounds per person based on a sample of 53 surveyed households representing 54 percent of households. The top 10 most commonly used resources for households were: caribou 88.7 percent, blueberry 69.8 percent, arctic grayling 67.9 percent, arctic char 64.2 percent, bowhead whale 60.4 percent, lake trout 54.7 percent, cloudberry 41.5 percent, Dall sheep 39.6 percent, ptarmigan 34.0 percent, with broad whitefish, arctic cisco, and crowberry tied for tenth place at 30.2 percent. Salmon were rarely harvested with salmon harvested outside of the North Slope. Harvest by usable weight in 2014 was dominated by large land mammals at 90 percent, followed by non-salmon fish at 8 percent, birds and eggs at 1 percent, and vegetation at 1 percent (Figure 5.6). Harvest for the top 10 resources by species in 2014 was primarily caribou at 84 percent (Table 5.5). Although annual harvests are highly variable, in general harvest per capita shows an increasing trend from 1992 to 2014 (Figure 5.2).
Figure 5.6.—Anaktuvuk Pass total community harvests in pounds, 1992 to 2014.

Table 5.5.—Top resource harvest in usable weight per person, Anaktuvuk Pass 2014.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Average Usable Weight per capita (pounds)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caribou</td>
<td>329.6</td>
<td>84%</td>
</tr>
<tr>
<td>Arctic char</td>
<td>12.2</td>
<td>3%</td>
</tr>
<tr>
<td>Lake trout</td>
<td>11.5</td>
<td>3%</td>
</tr>
<tr>
<td>Dall sheep</td>
<td>10.4</td>
<td>3%</td>
</tr>
<tr>
<td>Moose</td>
<td>9.5</td>
<td>3%</td>
</tr>
<tr>
<td>Arctic grayling</td>
<td>7.1</td>
<td>2%</td>
</tr>
<tr>
<td>Blueberry</td>
<td>1.5</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Eskimo potato</td>
<td>1.3</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Cloudberry</td>
<td>1.1</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Brown bear</td>
<td>1.0</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>All other resources</td>
<td>6.1</td>
<td>2%</td>
</tr>
</tbody>
</table>

Source: (Brown et al. 2016)

Note: top 10 resources, the "all other resources" category is all other resources that contributed less than 1% of the total harvest.
2. Nonlocal Fishing, Hunting, and Trapping

a. Sport Fishing

ADF&G’s Division of Sport Fish divides the state into management areas and subareas. The North Slope subarea covers waters north of the Brooks Range flowing into the Beaufort and Chukchi seas between Point Hope and the Canadian border including adjacent saltwater areas (ADF&G 2020e). Sport fishing effort in the North Slope subarea is generally light and focused on Dolly Varden, arctic char, lake trout, and arctic grayling in streams and lakes along the Dalton Highway (Scanlon 2018). The Dalton Highway crosses that Sale Area from about Milepost 265 (MP 265) to MP 352, from about the Atigun River bridge at MP 270 and north of Happy Valley along the Sagavanirktok River (ADF&G 2003).

Most (95 percent) sport fish harvest from freshwaters in the North Slope subarea is Dolly Varden/arctic char and arctic grayling, with sporadic harvest of chum salmon, lake trout, whitefish, northern pike and burbot (Table 5.6). On average, 62 percent of freshwater sport fishing effort in this subarea is concentrated on streams and lakes along the Dalton Highway, with 97 to 100 percent of fish released (Table 5.7), note that lake trout are catch-and-release only within 5-miles of the Dalton Highway. Although an average of about 950 anglers fished freshwaters of the North Slope during the 10-year period, the trend in fishing effort during 2009 to 2018 was declining at a rate of about 242 days fished per year (Figure 5.7).

Table 5.6.—North Slope subarea sport fishing freshwater effort and harvest, 2009 to 2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Anglers</th>
<th>Days Fished</th>
<th>Chum Salmon</th>
<th>Lake Trout</th>
<th>Dolly Varden/Arctic Char</th>
<th>Arctic Grayling</th>
<th>Whitefish</th>
<th>Northern Pike</th>
<th>Burbot</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>1,178</td>
<td>3,905</td>
<td>11</td>
<td>0</td>
<td>919</td>
<td>2,996</td>
<td>28</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>2010</td>
<td>970</td>
<td>4,384</td>
<td>0</td>
<td>117</td>
<td>223</td>
<td>608</td>
<td>0</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>2011</td>
<td>882</td>
<td>2,931</td>
<td>0</td>
<td>0</td>
<td>339</td>
<td>320</td>
<td>0</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>2012</td>
<td>1,354</td>
<td>4,968</td>
<td>0</td>
<td>112</td>
<td>594</td>
<td>892</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>832</td>
<td>2,881</td>
<td>0</td>
<td>0</td>
<td>192</td>
<td>939</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2014</td>
<td>1,155</td>
<td>3,641</td>
<td>0</td>
<td>90</td>
<td>430</td>
<td>416</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2015</td>
<td>1,020</td>
<td>2,758</td>
<td>0</td>
<td>98</td>
<td>286</td>
<td>314</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>961</td>
<td>4,052</td>
<td>0</td>
<td>0</td>
<td>599</td>
<td>457</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2017</td>
<td>722</td>
<td>2,138</td>
<td>0</td>
<td>0</td>
<td>158</td>
<td>343</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2018</td>
<td>389</td>
<td>1,231</td>
<td>0</td>
<td>0</td>
<td>179</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>946.3</td>
<td>3,286.2</td>
<td>1.1</td>
<td>41.7</td>
<td>391.9</td>
<td>734.7</td>
<td>2.8</td>
<td>1.4</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Source: (ADF&G 2020b)
Notes: Includes drainages north of the Brooks Range flowing into the Beaufort and Chukchi seas. Includes fresh and salt waters within and outside of the Sale Area.
Table 5.7.—Dalton Highway sport fishing effort, catch, and harvest, 2009 to 2018.

<table>
<thead>
<tr>
<th>Year</th>
<th>Days Fished</th>
<th>Lake Trout</th>
<th>Dolly Varden/Arctic Char</th>
<th>Arctic Grayling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FW Total</td>
<td>Dalton (%)</td>
<td>Catch (Harvest (%))</td>
<td>Catch (Harvest (%))</td>
</tr>
<tr>
<td>2009</td>
<td>3,905</td>
<td>1,813</td>
<td>67 0 0% 1,187 98 8%</td>
<td>5,810 454 8%</td>
</tr>
<tr>
<td>2010</td>
<td>4,384</td>
<td>3,746</td>
<td>129 0 0% 2,718 167 6%</td>
<td>10,735 474 4%</td>
</tr>
<tr>
<td>2011</td>
<td>2,931</td>
<td>1,801</td>
<td>0 0 0% 5,365 207 4%</td>
<td>2,797 165 6%</td>
</tr>
<tr>
<td>2012</td>
<td>4,968</td>
<td>2,516</td>
<td>93 0 0% 3,072 280 9%</td>
<td>12,901 424 3%</td>
</tr>
<tr>
<td>2013</td>
<td>2,881</td>
<td>1,523</td>
<td>221 0 0% 1,892 128 7%</td>
<td>2,954 266 9%</td>
</tr>
<tr>
<td>2014</td>
<td>3,641</td>
<td>2,046</td>
<td>57% 0 0% 1,429 123 9%</td>
<td>1,703 136 8%</td>
</tr>
<tr>
<td>2015</td>
<td>2,758</td>
<td>1,681</td>
<td>61% 0 0% 1,970 168 9%</td>
<td>3,625 119 3%</td>
</tr>
<tr>
<td>2016</td>
<td>4,052</td>
<td>2,971</td>
<td>73% 0 0% 2,927 502 17%</td>
<td>2,627 353 13%</td>
</tr>
<tr>
<td>2017</td>
<td>2,138</td>
<td>1,591</td>
<td>74% 0 0% 1,974 87 4%</td>
<td>5,330 303 6%</td>
</tr>
<tr>
<td>2018</td>
<td>1,231</td>
<td>474</td>
<td>39% 0 0% 429 41 10%</td>
<td>720 28 4%</td>
</tr>
<tr>
<td>Average</td>
<td>3,289</td>
<td>2,016</td>
<td>60% 0 0% 2,296 180 8%</td>
<td>4,921 272 6%</td>
</tr>
</tbody>
</table>

Source: (Scanlon 2018, 2020)
Notes: Includes drainages north of the Brooks Range flowing into the Beaufort and Chukchi seas. Includes fresh and salt waters within and outside of the Sale Area. FW = Freshwater, Dalton = Dalton Highway.

Figure 5.7.—North Slope subarea sport fishing freshwater effort and harvest, 2009 to 2018.
b. Hunting and Trapping – Nonlocal and Nonresident

All hunting and trapping of game animals within the Sale Area is managed by ADF&G. Hunting seasons and regulations are determined by the Alaska Board of Game and administered by ADF&G. Guided and unguided hunting by nonlocal and nonresident hunters occurs on state and federal lands. The state is divided into 26 game management units (GMUs or Units). All Arctic Ocean drainages between Cape Lisburne and the Alaska-Canada border are contained in GMU 26. ADF&G permits hunting and trapping on the North Slope in GMU 26, with some restrictions. Nonlocal and nonresident harvest is a minor component of the overall harvest of game animals within and near the Sale Area because most harvest is for subsistence by local residents.

The Sale Area is sandwiched between the National Petroleum Reserve – Alaska (NPR-A), Arctic National Wildlife Refuge (ANWR), and Gates of the Arctic National Park and Preserve (GAAR) and covers parts of GMU 26A and 26B. Portions of special management areas occur in the Sale Area including the Unit 26A and Anaktuvuk Pass Controlled Use Areas and the Dalton Highway Corridor Management Area (Figure 5.8). GMU 26A controlled use prohibits the use of aircraft to transport moose hunters and/or moose meat between January 1 and March 31 and July 1 and September 30. The Anaktuvuk Pass controlled use prohibits the use of aircraft to transport caribou hunters and/or caribou meat between August 15 and October 15. Hunting and off-road vehicle travel are prohibited within the Dalton Highway Corridor, a 5-mile corridor on either side of the highway, except that bow and arrow may be used to take big game, falcons may be used to take small game, and snowmachines may be used to cross the corridor to hunt outside of the corridor (ADF&G 2020a).

Hunting statistics are collected by ADF&G and are used to summarize harvest by GMU. Information on hunter residency, success, mode of transportation, and whether commercial services were used are collected (ADF&G 2020a). Caribou, moose, muskoxen, Dall sheep, brown bear, wolves, red fox, and ptarmigan are most likely to be harvested by nonlocal or nonresident hunters and trappers within or near the Sale Area.

Caribou hunting by nonlocal and nonresident hunters represents a small proportion of the total caribou harvest for GMU 26. Most hunting by nonlocal and nonresident hunters in the region occurs during August and September and is focused on the Central Arctic caribou herd (CAH) because much of this herd’s range is accessible from the Dalton Highway (Table 5.8). An average of 94 hunters, averaging a 70 percent success rate, hunted caribou in GMU 26A (Harper 2013; Dau 2015); and an average of 1,419 hunters, averaging a 48 percent success rate, hunted caribou in GMU 26B (Lenart 2015b) during regulatory years 2007 to 2013. Harvest reporting for the Western Arctic (WAH) and Teshekpuk caribou herds (TCH) are from GMU 26A, reporting for the CAH is from GMU 26B.

Few moose are hunted or harvested by nonlocal and nonresident hunters in GMU 26. During 2007 to 2013, an average of 10 nonlocal and nonresident hunters targeted moose in GMU 26A (Klimstra and Daggett 2020), and 3 or 4 bulls have been harvested annually during August and September in GMU 26A since 2015 (Table 5.8). Few to no moose have been harvested by nonlocal or nonresident hunters in GMU 26B during 2007 to 2013, and since the population decline in 2014 this subunit has remained closed to moose hunting by nonlocal and nonresident hunters (Lenart 2018; ADF&G 2020a).

Muskoxen harvestable surplus is reserved for subsistence use, the season for muskoxen was closed in GMU 26 in 2006 due to the decline in abundance of muskoxen (Lenart 2015c) and has remained closed.
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Figure 5.8.—Alaska Department of Fish and Game management units in the Sale Area.

Source: (ADF&G 2017)
**Dall sheep** hunting by nonlocal and nonresident hunters occurs during August and September. An average of 155 hunters harvested 40 Dall sheep per year in GMU 26B during 2011 to 2015, although general season hunters and harvest both declined over this 5-year period (Caikoski 2018). Most Dall sheep habitat and harvest in GMU 26B occurs within ANWR. Most Dall sheep habitat and harvest in GMU 26A is subsistence harvest within GAAR, with an average of 2.5 sheep per year on state lands in GMU 26A from 2007 to 2012 (Pamperin 2014). During 2015 to 2019, harvest in GMU 26B and 26A continued to decline to 19 sheep per year (Table 5.8). Most sheep hunters in the central Brooks Range use aircraft for transport to hunting areas (Pamperin 2014).

**Table 5.8.—Nonlocal game harvest in Game Management Subunits 26A and 26B, 2007-2008 to 2019-2020.**

<table>
<thead>
<tr>
<th>Regulatory Year</th>
<th>Western Arctic Herd</th>
<th>Teshekpuk Herd</th>
<th>Central Arctic Herd</th>
<th>Moose</th>
<th>Dall Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2008</td>
<td>103</td>
<td>5</td>
<td>690</td>
<td>7</td>
<td>59</td>
</tr>
<tr>
<td>2008-2009</td>
<td>84</td>
<td>4</td>
<td>717</td>
<td>7</td>
<td>59</td>
</tr>
<tr>
<td>2009-2010</td>
<td>70</td>
<td>4</td>
<td>815</td>
<td>8</td>
<td>54</td>
</tr>
<tr>
<td>2010-2011</td>
<td>63</td>
<td>3</td>
<td>1,238</td>
<td>10</td>
<td>64</td>
</tr>
<tr>
<td>2011-2012</td>
<td>93</td>
<td>5</td>
<td>1,172</td>
<td>4</td>
<td>57</td>
</tr>
<tr>
<td>2012-2013</td>
<td>85</td>
<td>5</td>
<td>1,007</td>
<td>5</td>
<td>66</td>
</tr>
<tr>
<td>2013-2014</td>
<td>111</td>
<td>6</td>
<td>854</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>2014-2015</td>
<td>115</td>
<td>6</td>
<td>916</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>2015-2016</td>
<td>115</td>
<td>6</td>
<td>764</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>2016-2017</td>
<td>155</td>
<td>8</td>
<td>589</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>2017-2018</td>
<td>74</td>
<td>4</td>
<td>231</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>2018-2019</td>
<td>68</td>
<td>4</td>
<td>219</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>2019-2020</td>
<td>69</td>
<td>4</td>
<td>287</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Average</td>
<td>92.7</td>
<td>4.9</td>
<td>730.7</td>
<td>4.7</td>
<td>39.9</td>
</tr>
</tbody>
</table>

Source: (Parrett 2009, 2015; Caikoski 2014, 2018; Pamperin 2014; Dau 2015; Lenart 2015b, 2018; ADF&G 2020d; Klimstra and Daggett 2020)
Notes: GMU 26B is closed to moose hunting.

**Brown bears** in GMU 26 are typically harvested during caribou hunts with an average of 32 brown bears harvested per year (Table 5.9). Nonlocal residents and nonresidents may harvest one bear each regulatory year, although nonresidents must be accompanied by a guide. Most of the harvests of brown bear in GMU 26B occurred in the Sagavanirktok, Ivishak, and Ribdon rivers. An average of 18 hunters harvested brown bears in GMU 26A (Carroll 2015) and 19 hunters harvested brown bears in GMU 26B (Lenart 2015a) during regulatory years 2007 to 2013. Most brown bears harvested in GMU 26B are taken by nonlocal resident hunters (Lenart 2015a). Brown bear harvest in GMU 26A is generally more evenly divided between nonlocal resident and nonresident hunters, with an average of 55 percent nonresident hunters (Carroll 2015).

Limited **furbearer** trapping takes place in the Sale Area, which encompasses portions of Region 5 – Arctic (GMU 26A) and Region 3 – Interior (GMU 26B). Few to no survey respondents were identified as trapping within GMU 26 over the 12-year period reported in Table 5.9, and as with
hunting, the primary use for furbearers in this region is subsistence. In Region 5, which includes GMU 26A, the red fox ranks first as the most targeted furbearers according to the trapper survey (Parr 2017). Foxes are taken primarily by trapping and shooting with an average estimate of 64 red foxes harvested per year (Table 5.9). Other furbearers that regularly occur in the Sale Area and are reported as harvested by trapper questionnaire respondents in GMU 26 include an estimated average of 31 wolves per year and 15 wolverine per year (Table 5.9).

Table 5.9.—Nonlocal brown bear and estimated furbearer harvest in Game Management Subunits 26A and 26B, 2007-2008 to 2019-2020.

<table>
<thead>
<tr>
<th>Regulatory Year</th>
<th>Brown Bear</th>
<th>Red Fox</th>
<th>Wolf</th>
<th>Wolverine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007-2008</td>
<td>13</td>
<td>24</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>2008-2009</td>
<td>37</td>
<td>83</td>
<td>109</td>
<td>55</td>
</tr>
<tr>
<td>2009-2010</td>
<td>32</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2010-2011</td>
<td>35</td>
<td>0</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>2011-2012</td>
<td>38</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>2012-2013</td>
<td>42</td>
<td>176</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>2013-2014</td>
<td>43</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2014-2015</td>
<td>37</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2015-2016</td>
<td>44</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2016-2017</td>
<td>39</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2017-2018</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2018-2019</td>
<td>25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2019-2020</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>32.4</td>
<td>63.8</td>
<td>30.8</td>
<td>15.2</td>
</tr>
</tbody>
</table>

Source: (Schumacher 2010a, b, 2012, 2013a, b; Harper and McCarthy 2013; Carroll 2015; Lenart 2015a; Parr 2016, 2017, 2018; ADF&G 2020c; Daggett 2020)
Notes: * no trapper reports prepared; - no respondents from GMU 26.

Limited small game hunting for ptarmigan and snowshoe hare takes place in the Sale Area (Merizon and Carson 2013; Merizon et al. 2015). About 1 percent of the 40,239 estimated total small game hunters in 2013 hunted in GMU 26 for a total of about 25 days hunting ptarmigan and 10 days hunting snowshoe hare. Hunters accessed hunting areas by highway vehicle and on foot for ptarmigan, and used snowmachines to access hunting areas for snowshoe hare (Merizon et al. 2015). Small game hunters using GMU 26 included Kenai, Anchorage, Matanuska-Susitna, and Interior rural region resident and nonresident hunters in 2013 (Merizon et al. 2015).

B. Recreation and Tourism

Alaska is tied with Montana, ranking first with 81 percent of Alaskans participating in outdoor recreation. Opportunities to get outside are a reason many Alaskans choose to live or remain in the state, and a similar share of visitors include outdoor recreation with their trip (UAA 2019). Outdoor recreation for visitors to the North Slope includes wildlife viewing, hiking, camping, rafting, fishing, and hunting. Tourist visits to ANWR averaged about 1,155 people, while visitation to
GAAR averaged about 10,912 people over the past 10-years (USFWS 2020; NPS 2020). Most visitors come to ANWR and GAAR during June to September. Most visitors to ANWR participate in polar bear viewing near Kaktovik 63 percent, followed by floating rivers 14 percent, hunting 10 percent, and hiking/backpacking 8 percent (USFWS 2020). Most visitors to GAAR (62 percent) are backcountry campers. Access to ANWR is primarily through commercial operators that transport visitors into the refuge by plane. Visitation was expected to increase in ANWR as users discovered direct access to ANWR via the Dalton Highway near Atigun Gorge (USFWS 2010, 2020). During 2010 to 2019, an average of 56 visitors per year accessed ANWR from the Dalton Highway, which increased from 48 per year during the first 5-year period to 63 per year during the second 5-year period (USFWS 2020).

Several tour companies offer trip packages that include visits to communities such as Utqiaġvik, Anaktuvuk Pass, and Kaktovik; trips on the Dalton Highway to the Arctic Circle, Prudhoe Bay, and Arctic Ocean; and custom planned trips into remote locations in the region (Fix 2014). The Dalton Highway was designated a state scenic byway in 1998 and is one of only two roads that cross and continue north of the Arctic Circle in North America (DNR 2010). The Dalton Highway runs for 414 miles from Livengood to Prudhoe Bay, crossing the Sale Area for about 88 miles from MP 265 to MP 353. Most traffic on the Dalton Highway is commercial trucks delivering supplies and fuel to the North Slope oil fields. Driving the Dalton Highway is considered a life-list accomplishment by many recreational visitors (Fix 2014). Tourist traffic, including motorcyclists and bicyclists, has been increasing steadily after the highway was opened to the public in 1994 (DOT&PF 2020). Recreational traffic has increased in the Sale Area near MP 339 at a rate of 2.4 passenger cars, pickups, vans, and recreational vehicles per week per year between 2009 and 2019 (Vockeroth 2020). In the section of Dalton Highway north of the Brooks Range that crosses the Sale Area visitors were primarily Alaskans, were repeat visitors, and use was highest in August when many visitors hunted for caribou or other game (Fix 2014).

The Simon Paneak Memorial Museum, in the village of Anaktuvuk Pass, is operated by the Iñupiat History, Language, and Culture department of the NSB. The museum’s purpose is to assemble, preserve, and understand materials associated with the culture, lifestyle, and history of the Nunamiut Iñupiat people. The museum includes the Hans Van Der Laan Brooks Range Library that contains scientific and reference materials related to the region. The primary focus of the museum is document the importance of caribou to the local people’s culture and economy (NSB 2017).

Summer statewide Alaska visitor volume increased at an annual rate of 3.7 percent over the past 10-year period from 2010 to 2019 with an estimated 2.2 million visitors during 2019 (McDowell Group 2020). Based on the last summer visitor profile conducted for 2016, 2 percent or 33,000 visited the Far North region, that includes both northwestern Alaska (Nome), and the entire region north of the Arctic Circle. Of the estimated 33,000 Far North visitors, an estimated 12,000 visited Coldfoot, south of the Sale Area on the Dalton Highway. One in four Far North visitors (26 percent) were business travelers, 4 percent were traveling for business or pleasure, 14 percent were visiting friends or relatives, while 56 percent were traveling for vacation or pleasure; and 27 percent purchased a multi-day package with a cruise compared to 64 percent for all Alaska visitors. The average length of stay among Far North travelers was 15.7 nights. Most (85 percent) Far North visitors lodged in a hotel or motel during their stay, while 25 percent stayed with friends or family, in contrast to 52 percent and 15 percent for all Alaska visitors, respectively. Over half of Far North visitors traveled between communities by air compared to 9 percent for all Alaska visitors. The most popular Far North summer activities were wildlife viewing, cultural activities, and hiking or nature walk, while 16 percent of visitors went fishing in the region. Far North visitors reported spending an average of $2,431 on their Alaska summer trip, much higher than the average Alaska visitor who reported spending $1,057 (McDowell Group 2017).
Fall/winter statewide Alaska visitor volume increased at an annual rate of 3.1 percent over the past 10-year period from 2009-2010 to 2018-2019 with an estimated 323,000 visitors during 2018-2019 (McDowell Group 2020). Based on the last fall/winter visitor profile conducted for 2011-2012, 6 percent or 15,000 visited the Far North, with 4 percent visiting places outside of Nome. Few (3 percent) visitors purchased multiple-day trip packages, 67 percent were traveling primarily for business, and 6 percent of the total international market visited the Far North. Far North visitors stayed an average of 19.4 nights, and 85 percent were repeat visitors. Far North winter recreation activities included shopping (49 percent), wildlife viewing (27 percent), northern lights viewing (12 percent), museums (7 percent), hiking/nature walks (4 percent) and winter sports including dog mushing (11 percent), snow machining (8 percent), and skiing or snowboarding (2 percent). Visitors spent an average $1,076 in Alaska on their winter trip, and $550 in a community, most of which was multiday packages attributable to one community (McDowell Group 2012).

C. Research Natural Area

The Toolik Lake Field Station, an ecological research facility managed by the University of Alaska, Institute of Arctic Biology, supports field studies for more than 100 scientists and their students (UAF 2020). Located at MP 284 on the Dalton Highway, the field station was originally established to support aquatic research to obtain baseline data on the North Slope and inland coastal ponds (Huryn and Hobbie 2012; UAF 2020). Toolik Lake was selected as the site for the aquatic research and a survey of ecological and limnological sites from the Brooks Range to Prudhoe Bay was made in 1975. Toolik Field Station has developed from a ten-person tent camp into a premier arctic research laboratory over the past 45 years (UAF 2020). The entire Toolik Lake watershed and the adjacent upper Kuparuk River watershed was established as the Arctic Long Term Ecological Research (LTER) site within the National Science Foundation’s LTER network in 1987 (NSF 2019). Research topics include: atmospheric and physical sciences; terrestrial and aquatic ecology; and the physiology of arctic breeding birds, mammals and insects (NSF 2019).

D. Renewable Energy

1. Wind

Across Alaska, wind energy provides about 64 megawatts of generating capacity with more than 100 wind turbines. Increasing numbers of small-scale wind energy facilities, including some hybrid systems that use diesel and wind, are supplying power to rural communities. Increasingly small wind energy facilities, including wind-diesel hybrid systems, provide power to off-grid rural communities throughout the state (EIA 2019).

According to the North Slope Regional Energy Plan, wind resource studies were conducted in six North Slope communities; and completed wind resource reports exist for the villages of Anaktuvuk Pass, Atqasuk, and Kaktovik. Communities near the coast such as Utqiâ’vik and Kaktovik experience higher winds than inland communities such as Anaktuvuk Pass or Atqasuk (WHPacific 2015). The potential for wind generated power in the Sale Area is primarily poor, with a few areas of marginal and fair potential (Figure 5.9).
Figure 5.9.—Wind power potential in the Sale Area.

Source: (AEA 2020)
2. Solar

Solar energy provides electricity in remote locations across the North Slope of Alaska and is vital for many remote project sites. Both the design of buildings to collect passive solar energy and the use of photovoltaic panels help to reduce the need for more traditional fuels. The main uses for solar energy technology are for heating buildings and hot water sources (EIA 2019). Average annual solar insolation, the measure of the amount of solar radiation received on a given surface area, in the Sale Area ranges from 2 to 4 kilowatt hours per square meter per day. Remote applications such as fish camps, lodges and cabins can be ideal for solar photovoltaic systems in northern Alaska (AEA 2019).

The Cold Climate Housing Research Center has performed extensive work on researching the feasibility of solar energy in the extreme latitudes found in the North Slope region. The main challenge is that there are minimal solar resources available during the winter when the demand for energy is the highest, and there is an abundance of solar energy available in the summer months when the demand for energy wanes. However, the research shows that solar power can be successful in small scale projects based on observations from several North Slope projects (CCHRC 2020).

The Alaska Center for Energy and Power conducted a case study on solar technology in remote areas in northern Alaska and examined several installations ranging in size from 2.2 to 50 kilowatts. Because of the cold temperatures and presence of snow, the system voltage is increased, electrical resistance is reduced, and the reflection of light off the snow leads to higher solar radiation that can be captured by the photovoltaic cells. The case study reviewed data from many small communities in northern Alaska including Ambler, Kobuk, Nome, Galena, and Bethel among others. The study showed an offset in annual diesel use ranging from 157 gallons to 895 gallons, with an average offset of over 500 gallons per system (Whitney and Pike 2017).

E. Transportation and Resources Projects

Lands in the Sale Area have been used to construct the Hickel Highway and the Dalton Highway and for the development of transportation corridors including Arctic Strategic Transportation and Resources (ASTAR) projects, Community Winter Access Trail (CWAT) to Anaktuvuk Pass, and the Foothills West Transportation Access project from Galbraith Lake to Umiat (Figure 5.10). The Hickel Highway was constructed in 1968 to support exploration and development of the Prudhoe Bay oil field. This road was abandoned after construction of the Dalton Highway (DOT&PF 2020).
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Figure 5.10.—Existing and proposed transportation facilities in the Sale Area.
1. Arctic Strategic Transportation and Resources

In partnership with the North Slope Borough and in collaboration with area communities and other key stakeholders, ASTAR seeks to identify, evaluate, and advance community infrastructure and regional connectivity projects that offer the greatest benefits to the region. The route to connect Anaktuvuk Pass (Figure 5.10) to the Dalton Highway would cross through the Sale Area (DNR 2020a).

ASTAR will gather regional information through community engagement, provide for analysis of existing data, and develop relevant reports and field studies which can be beneficial to infrastructure projects identified throughout the region. Gaps in technical information necessary to support future infrastructure projects will be identified and when necessary, additional data will be collected across the region. ASTAR’s review will encompass the entire North Slope Borough, including the NPR-A, ANWR, and other federal lands and waters. ASTAR will use a cumulative benefits analysis – advancing projects that seek to provide the greatest benefits to North Slope people and communities and will significantly inform state and local discussions with federal agencies regarding their land management activities in the region (DNR 2020a).

Projects that achieve the greatest cumulative benefits and receive local support will move to ASTAR’s advanced pre-implementation stage. This includes identifying potential funding sources, project sponsors, obstacles and challenges, and analyzing permitting and data gaps. As appropriate, additional ASTAR work may be conducted to fill these gaps. Desired outcomes for the ASTAR project include increased cultural connectivity, reduced cost of living in area communities, decreased rehabilitation costs for NPR-A legacy wells, more efficient development of state and federal natural resources, and increased economic activity providing job opportunities for the region (DNR 2020a). ASTAR is a 3-year project funded through a re-appropriation of $7.3 million through fiscal year 2020.

2. Community Winter Access Trail

The purpose of the CWAT program is to connect residents of the communities of Utqiagvik, Atqasuk, Wainwright, Nuiqsut and Anaktuvuk Pass to the state road system by use of improved snow trails. The trails establish an alternative to expensive air freight to satisfy community supply needs for fuel, building materials, and other supplies. CWATs support local and regional community economic development opportunities in Alaska Native communities including personal vehicle use and freight hauling. During multiple years of route development, the project can identify preferred routing for a permanent transportation corridor and potential material sites for construction (BLM 2019).

NSB initiated a 5-year pilot project in 2018 to develop snow roads between North Slope communities and the Dalton Highway. CWATs allow for regular caravan transits to and from the communities to the Dalton Highway and provide safe overland access. CWAT goals are to: provide an alternative to air freight and seasonal barge hauling; establish the viability of seasonal overland transportation; support local and regional economic development; and identify preferred routing for permanent transportation corridors. During the winters of 2017-18 and 2018-2019, NSB built approximately 300 miles of roads connecting Utqiagvik, Atqasuk, Wainwright, Nuiqsut and Anaktuvuk Pass (Figure 5.10) at a cost of about $5,000 per mile (PDC Engineers 2019).

3. Foothills West Transportation Access

The purpose of the Alaska Department of Transportation and Public Facilities’ (DOT&PF) Foothills West Transportation Access project was to develop an industrial transportation corridor
from the Dalton Highway to the Gubik oil and gas fields at Umiat that includes an all-season road, accommodates oil and gas pipelines and associated facilities, and establishes material sites. After studies and review, a route from Galbraith Lake between the Itkilik and Anaktuvuk rivers to Umiat (Figure 5.10) was preferred due to fewer river crossings, material sites and geology, and land ownership (DOT&PF 2010; Anderson 2011). Although studies were completed, permitting and construction were halted due to a lack of funding.

### F. Mining

Commercial development of Alaska’s coal resources began in 1855. The North Slope coal province contains an identified 120 billion short tons, and a hypothetical 3.9 trillion short tons of high quality, locatable bituminous and subbituminous coal (Flores et al. 2004; Stricker et al. 2011). The Northern Alaska-Slope coal province extends into about 57 percent of the Sale Area (Figure 5.11) and contains coal deposits from the Kekiktuk Formation, the Nanushuk Formation, the Prince Creek Formation, and the Sagavanirktok Formation (Stricker et al. 2011). Coal deposits from the Nanushuk and Prince Creek Formations are found within the area between the Brooks Range and the Barrow Arch known as the Colville Basin. Nanushuk Formation deposits are thick within the western portion of the North Slope coal province and gradually thin toward the eastern portion of the province in the Sale Area (Stricker et al. 2011).

High value coal deposits can be found on State owned and/or State selected lands in the Central Slope and Brooks Foothills regions. These coal deposits potentially have high commercial and economic value because of their thermal and coking potential. Currently, however, these coal deposits are not considered a significant resource in the North Slope planning area as there is currently little interest in these resources (DNR 2020b). A coal prospecting permit application for 116,000 acres (ADL 418931) of state lands along an east-west belt on the north flank of the Brooks Range within the Sale Area was received in 2008. On July 22, 2010 the Final Nanushuk Site Specific Plan and Land Classification Order Number NC-10-002 was issued and was subsequently appealed. The permit requestors failed to respond to inquiries concerning their interest in continuing to pursue the permit request in 2013, and the land classification and prospecting permit were vacated and void (DNR 2019). Coal exploration, development, and extraction are governed by a mix of statutory (AS 38.05.150 and AS 27.21.010-.260) and administrative (11 AAC 85 and 11 AAC 90) requirements, which must be followed for exploration and for subsequent extraction to be authorized (DNR 2020b).

Development of locatable minerals has been considered important for the settlement and economy of Alaska, although there has been little interest or exploration, and no mining operations within the North Slope planning area (DNR 2020b). Known mineral deposits in the Sale Area are shown on Figure 5.11.
Figure 5.11.—Northern Alaska-Slope coal province and mineral deposits in the Sale Area.

Source: (USGS 2005; Stricker et al. 2011)
G. References


ADF&G (Alaska Department of Fish and Game). 2017. Game management units. Game management unit information.


ADF&G (Alaska Department of Fish and Game). 2020e. North Slope management area - overview.


DNR (Alaska Department of Natural Resources). 2020a. Arctic Strategic Transportation and Resources cascade story map. Last Modified July 2, 2020. https://www.arcgis.com/home/item.html?id=ab8be9349a08477ebfb66d017e0aesc8d.

Chapter Five: Current and Projected Uses in the Sale Area


Chapter Five: Current and Projected Uses in the Sale Area


# Chapter Six: Petroleum Potential, Operations, and Transportation Methods in the Sale Area

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<td>ii. Roads</td>
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As required by AS 38.05.035(g)(1)(B)(ii) and (viii), this chapter considers and discusses the petroleum potential of the North Slope Foothills Areawide lease sale area (Sale Area); and the methods most likely to be used to transport oil or gas from the area with a discussion of the advantages, disadvantages, and relative risks of methods of transportation. The following discussions provide a general overview of petroleum potential, petroleum exploration within the Sale Area, and the methods most likely to be used to transport oil or gas from the Sale Area. This discussion is not intended to be all inclusive. Because there is a risk of a spill any time crude oil or petroleum products are handled, AS 38.05.035(g)(1)(B)(vii) requires the director to consider and discuss lease stipulations and mitigation measures to prevent and minimize releases of oil and hazardous substances, and to discuss the protections offered by these measures.

A. Petroleum Geology

1. Regional Framework

The Sale Area is a subset of the Arctic Foothills physiographic region, which is part of Alaska's east-west trending Arctic Alaska Petroleum Province (Plafker and Berg 1994; Houseknecht and Bird 2006). Nestled between the Brooks Range to the south and the Coastal Plain to the north, the Arctic Foothills physiographic region encompasses more than 40,000 square miles. These lands include Sale Area, the southern portion of the North Slope Areawide, greater than half the federally managed National Petroleum Reserve – Alaska (NPR-A) lands, the southern portion of Arctic National Wildlife Refuge (ANWR) Coastal Plain (formerly known as the 1002 area), various native corporation lands, and lands of mixed ownership on western-most North Slope (Figure 6.1).
Chapter Six: Petroleum Potential, Operations, and Transportation Methods in the Sale Area

Source: (modified from Gregersen and Brown 2019)
Figure notes: Hill shade map showing the Sale Area (light gray) and the three North Slope physiographic regions: Brooks Range (mountain range to the south), Arctic Foothills (folded region north of the Brooks Range as shown by anticlinal lineation trends), and Arctic Coastal Plain (north of the blue dashed line). Colored circles represent exploration wells drilled through December 2018. Colors represent the targeted stratigraphic play type: yellow = Brookian topsets; orange = Brookian turbidites; green = Cretaceous rift rocks; blue = Jurassic shoreface rocks; purple = Ellesmerian clastic and carbonate rocks; and gray = other targets such as basement, gas hydrates, and coal bed methane. Red circles are wells under extended confidentiality with the AOGCC. The dashed black line represents the anticlinal trace of the Barrow Arch.

2. Tectonic and Geologic History

The Arctic Foothills regional depositional history is divided into four main sequences distinguished by sediment provenance, depositional style, and tectonics (Figure 6.2). These four sequences are listed (oldest to youngest) and discussed below.

The Franklinian sequence consists of fractured argillites, quartzites, carbonates, volcanics, and granitic rocks that once composed a stable continental platform prior to Devonian time 400 million years ago. The Franklinian sequence includes the oldest sedimentary rocks in the Arctic Foothills physiographic region and is considered effective basement for oil and gas potential. It is unlikely to contain any significant oil or gas accumulations in the Sale Area; however, if such accumulations are present, they would likely be in the form of fractured reservoirs. During Late Devonian time, the Franklinian sequence was uplifted and deformed with coincident erosion of this uplifted sequence providing the dominant sediment source for the Ellesmerian sequence.

The Ellesmerian sequence consists of marine carbonates and clastic rocks rich in quartz and chert that were deposited on a subsiding foldbelt terrain for 150 million years during Mississippian to Early Jurassic time. It is subdivided into a lower and upper section. The lower Ellesmerian section contains proven oil and gas accumulations in the Coastal Plain region, such as the Endicott, Lisburne, and Liberty oil fields. The upper Ellesmerian section contains proven oil and gas accumulations such as the Prudhoe Bay, Northstar, and Raven oil fields and the Kemik, Kavik, and Sandpiper gas fields. The Shublik Formation and Sadlerochit Group are two of the most continuous rock units in this section. The Ellesmerian sequence thins to the south due to increasing distance from its source area and thins to the north due to the combined effects of onlap, subaerial uplift, and erosion prior to deposition of the Beaufortian Rift sequence (Moore et al. 1994).

The Beaufortian sequence consists of marine shales, siltstones, and sandstones sourced from the Barrow Arch rift shoulder. Oil and gas accumulations adjacent to the Barrow Arch are contained in purely stratigraphic or combination structural/stratigraphic traps formed by associated rifting events; however, in the foothills proper, structural traps form the dominant play. The Beaufortian sequence contains proven oil and gas accumulations within the Cretaceous and the Jurassic such as the Kuparuk, Point McIntyre, Milne Point, Fiord-Kuparuk, Nanuq-Kuparuk, Niakuk, Alpine and Fiord-Nechelik oil fields and the East Barrow, South Barrow, and Walakpa gas fields. The Kingak Shale and pebble shale unit (informal name) are two of the most continuous rock units in this sequence.

The Brookian sequence consists of marine shales, siltstones, and sandstones sourced from the Barrow Arch rift shoulder. Oil and gas accumulations adjacent to the Barrow Arch are contained in purely stratigraphic or combination structural/stratigraphic traps formed by associated rifting events; however, in the foothills proper, structural traps form the dominant play. The Beaufortian sequence contains proven oil and gas accumulations within the Cretaceous and the Jurassic such as the Kuparuk, Point McIntyre, Milne Point, Fiord-Kuparuk, Nanuq-Kuparuk, Niakuk, Alpine and Fiord-Nechelik oil fields and the East Barrow, South Barrow, and Walakpa gas fields. The Kingak Shale and pebble shale unit (informal name) are two of the most continuous rock units in this sequence.

The Brookian sequence consists of sandstones that contain significantly less quartz and more ductile rock fragments than sandstones of the Ellesmerian sequence. Development of the Brookian sequence involved enormous amounts of sediment which were shed northward into the adjacent foredeep from the developing Brooks Range orogenic belt during Jurassic to Early Cretaceous time. These sediments filled the Colville Basin to the north and then spread out over the Barrow Arch and onto the continental margin during Late Cretaceous to Tertiary time (Moore et al. 1994). The Brookian sequence contains proven oil and gas accumulations such as the West Sak, Schrader Bluff, Tabasco, Tarn, Meltwater, Qannik, Umiat, Fish Creek, and Simpson oil fields and the East...
Umiat, Gubik, Square Lake, Wolf Creek, Oumalik, and Meade gas fields. New discoveries at Pikka and Willow are in the Brookian sequence.

Petroleum source rock facies of the Shublik Formation, Kingak Shale, pebble shale unit, and Hue Shale (gamma ray zone) and younger basinal shales of the Brookian sequence (Figure 6.2) are all likely to have generated gas and/or oil within the Arctic Foothills region, based on organic richness, kerogen composition, and thermal maturity determined from well and outcrop samples. The data suggest these rocks currently reside principally within the gas window and partially within the oil window (Bird 1994, 2001; Peters et al. 2006).

3. Petroleum Potential

The potential for new discoveries of conventionally recoverable petroleum in the Sale Area, located in the Arctic Foothills physiographic region is relatively high for gas, and relatively low for oil. Determining petroleum potential requires evaluation of the geology, geophysics, and exploration history of an area, which in this case requires analysis of data that are sparsely distributed and, in many cases, antiquated by today’s standards, making it a difficult task.

Except for the Umiat oil accumulation, discoveries to date within the Arctic Foothills physiographic region consist primarily of dry gas trapped in anticlinal fold closures, most of which were identified from early surface geologic mapping supported by two-dimensional reflection seismic surveys (Figure 6.1). This is strong evidence, corroborated by outcrop and well data, that many of the source rocks in the Arctic Foothills have reached advanced thermal maturity due to deep sediment burial, and that major new oil finds are unlikely. On the basis of geochemical and stratigraphic

Figure 6.2.—Stratigraphic column with petroleum systems for northern Alaska.
evidence, the hydrocarbons in the accumulations west of the Dalton Highway are traced to Lower Cretaceous shale source rocks of the gamma ray zone and lower Torok Formation at the base of the Brookian sequence (Magoon et al. 2003). These western accumulations are reservoired in Brookian topset sandstones of the Nanushuk and Tuluvak Formations (Figure 6.2). These units are largely to entirely absent to the east of the Dalton Highway, though younger Brookian units are present that may have untapped potential.

A petroleum systems approach is useful for evaluating the undeveloped resource potential of areas such as the Arctic Foothills physiographic region that have not yet reached an advanced stage of exploration. This methodology considers and quantifies each of the interdependent elements of the overall geologic framework that together create producible accumulations of oil and gas. There are three basic elements of functioning petroleum systems: effective source rocks to generate oil and gas in the thermally mature area of the basin (referred to as the petroleum “kitchen”), effective reservoir rocks with pore space to store them in, and effective traps, the sealed compartments that contain hydrocarbon fluids, preventing their escape. Each of these three components must be physically connected to the others at the critical moment, the brief episode during the system’s geologic history when hydrocarbons are generated, migrate out of their source rock, and in favorable outcomes, encounter reservoirs in trapping configurations.

An important distinction must be drawn between resources and reserves. In North America, and most other countries, the term “reserves” is restricted to discovered, well-quantified, technically recoverable volumes that are nearly certain to reach commercial production. All other oil and gas, whether discovered or yet-to-be found, belongs in one of the various “resource” categories (SPE 2018). In keeping with these definitions, oil and gas volumes discovered to date in the Arctic Foothills region are currently best described as “sub-commercial resources” whose development potential is contingent upon constantly fluctuating economic factors and connection to markets. Wellhead proximity to existing oil or gas infrastructure directly affects the size of the resource required to make a project economic. Due to the remoteness of the Sale Area from existing oil and gas infrastructure, any discovered resource needs to be of sufficient size to economically justify production.

B. Oil and Gas Development on the North Slope

1. Exploration History

Oil seeps have long been known to the Inupiat people of the North Slope, who excavated tar-saturated tundra for use as fuel. Following reports of oil seeps along the coast by early traders, the first geologic and topographic studies were conducted in 1901. The US Geological Survey (USGS) produced the first formal descriptions of the geology of the North Slope in 1919. By 1921, prospecting permits were filed and, in 1923, President Harding created the Naval Petroleum Reserve Number 4 (NPR-4) by executive order. The Arctic Foothills region was considered prospective for hydrocarbon exploration as early as the 1920s because of widespread discernable surface anticlinal structures in the area. USGS spent the summers of 1923 to 1926 conducting reconnaissance surface-mapping in the foothills.

The first exploration phase of NPR-4, known today as the National Petroleum Reserve – Alaska, ended in 1953. Between 1923 and 1953, the US Navy drilled 37 test wells and found three oil accumulations and five gas accumulations within and adjacent to the reserve (Schindler 1988; Bird 1994). Only two of these discoveries were considered sizable: Umiat with an estimated 70 million barrels of recoverable oil and Gubik with an estimated 600 billion cubic-feet of recoverable gas.
The Umiat oil and Gubik gas accumulations are located near the westward bend in the Colville River (Table 6.1).

The Bureau of Land Management (BLM) opened North Slope lands for competitive bidding in 1958 when 16,000 acres were offered near the Gubik gas field. That same year, the BLM opened 4 million acres in NPR-A, northwest of the Sale Area, for simultaneous filing and subsequent drawing. Building on the exploration drilling efforts of the US Navy, private industry began exploratory drilling in the mid-1960s. In 1964, six wells were drilled by various companies within the Sale Area. Drilling was focused where surface expressions indicated anticlinal structure, following the pattern set by the US Navy. Although hydrocarbon shows were present in each of the six wells drilled, no oil fields and only one sub-commercial gas field (East Umiat) were identified as a result of this work. The East Umiat gas field (Table 6.1) is located in topset (shallow water) sandstones of the Nanushuk Formation within the Cretaceous aged Brookian sequence (Figure 6.2). A second pulse of exploratory drilling occurred from 1969 to 1971. Four wells were completed within the Sale Area during this time, but none led to any further activity.

Following a succession of dry holes in the Arctic Foothills, exploration shifted northward to the Arctic Coastal Plain. In 1965, the first holes drilled in the area immediately surrounding the Prudhoe Bay structure came up dry. In January 1967, a rig was moved to the Prudhoe Bay State No.1 location near the mouth of the Sagavanirtok River, culminating in the discovery of commercial oil deposits at Prudhoe Bay by Atlantic Richfield in 1968. After the Prudhoe Bay discovery, exploration activity increased dramatically and led to the discovery of the Kuparuk River field in 1969. Between 1967 and 1979, more than 100 exploratory wells were drilled on the North Slope (AOGCC 2019b; Gregersen and Brown 2019), with 23 regarded as new oil or gas discoveries. Oil production began in Prudhoe Bay with the completion of the Trans-Alaska Pipeline System (TAPS) on June 20, 1977.

From 1974 to 1982, 11 additional exploratory wells were drilled in the Sale Area. The East Kurupa Unit 1 well resulted in the discovery of the East Kurupa gas accumulation (Table 6.1), which occurs near the base of the Brookian sequence in bottomset (deep water) sandstones assigned to the lower Torok Formation or the Fortress Mountain Formation (Figure 6.2). The undeveloped Kemik gas field (Table 6.1), located east of the Dalton Highway near ANWR in the foothills of the northeastern Brooks Range (Figure 6.2), is contained in fractured, low permeability rocks of the Triassic Shublik Formation belonging to the Ellesmerian sequence, the oldest stratigraphic series with commercial hydrocarbon significance in northern Alaska. The gas at Kemik is believed to have been sourced from organic rich shales and limestones of the Shublik Formation (Magoon et al. 2003; Schenk and Houseknecht 2008), with minimal migration from kitchen to reservoir. The Lisburne 1 well, completed in 1980 by Husky, was drilled as part of the USGS-led NPR-A exploration program. The boundary of NPR-A was later adjusted in that area, and the Lisburne 1 well now lies just within the western boundary of the Sale Area. This well tested the hydrocarbon potential of the Lisburne carbonates on a closed anticlinal structure in the overthrust belt on the western edge of the Sale Area. Minor gas shows were encountered in poor reservoir-quality rocks throughout the well (Legg 1983). Chevron drilled three wells on Arctic Slope Regional Corporation (ASRC) land: the Tiglukpuk 1 well in 1978, the Killik 1 well in 1981, and the Cobblestone 1 well in 1981/1982. The Big Bend 1 well was drilled by ARCO on ASRC land in the Sale Area in 1993.

The last wells drilled in and near the Sale Area were the Chandler 1 well by Anadarko Petroleum Corporation and the Gubik 3 and 4 wells by Anadarko Petroleum Corporation in 2008/2009. The Chandler 1 well targeted the flank of the East Umiat anticline and established the presence of a deeper bottomset (deep water) gas reservoir likely of the Torok Formation and/or Fortress Mountain Formation (Lidji 2009; OGJ editors 2009). The Gubik 3 and 4 wells were drilled and
completed in the Gubik gas field north of the Sale Area (AOGCC 2019b; Gregersen and Brown 2019).

### Table 6.1.—Known oil and gas accumulations within and near the Sale Area.

<table>
<thead>
<tr>
<th>Discovery Year</th>
<th>Accumulation Name (Areawide)</th>
<th>Status</th>
<th>Proportion on State Lands (%)</th>
<th>Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>Umiat Oil Pool (FH)</td>
<td>Not Producing</td>
<td>9%</td>
<td>Nanushuk Group</td>
</tr>
<tr>
<td>1951</td>
<td>Gubik Gas Pool (NS)</td>
<td>Undeveloped</td>
<td>10%</td>
<td>Colville and Nanushuk Groups</td>
</tr>
<tr>
<td>1972</td>
<td>Kemik Gas Field (NS)</td>
<td>Abandoned</td>
<td>25%</td>
<td>Shublik</td>
</tr>
<tr>
<td>1976</td>
<td>East Kurupa Gas Pool (FH)</td>
<td>Undeveloped</td>
<td>0%</td>
<td>Fortress Mountain – Torok</td>
</tr>
<tr>
<td>1984</td>
<td>East Umiat Gas Pool (FH)</td>
<td>Shut In</td>
<td>0%</td>
<td>Nanushuk Group</td>
</tr>
</tbody>
</table>

Source: (Thomas et al. 2009)

Areawide: NS = North Slope, FH = North Slope Foothills

### 2. Infrastructure on the North Slope

The North Slope hosts an extensive network of petroleum production, development, and support facilities, all leading to the TAPS gathering facility, into the pipeline, and, ultimately, the TAPS terminal in Valdez. Prudhoe Bay and Deadhorse continue to function as the hub of activity for the 35 fields and satellites on the North Slope and in the Beaufort Sea, extending outward via roads, pipelines, production and processing facilities, gravel mines, and docks. Deadhorse houses an industry-support community and airport.

As exploration and development have continued, oil companies – and regulatory agencies – have capitalized on technological advances that allow for reduced pad sizes and capitalizing on existing infrastructure, thus minimizing further environmental impacts. Oil and gas infrastructure in the Sale Area includes TAPS from about Milepost (MP) 64 to MP 150, TAPS Pump Stations 3 and 4, and associated infrastructure. A total of 25 exploration wells have been drilled in the Sale Area since 1952. All 25 exploration wells in the Sale Area have been located on either federal (prior to ANILCA) or ASRC lands. Information for three of these wells has remained indefinitely confidential (20 AAC 25.537(d); Figure 6.3).
Chapter Six: Petroleum Potential, Operations, and Transportation Methods in the Sale Area

NORTH SLOPE FOOTHILLS AREAWIDE OIL AND GAS LEASE SALES | Final Finding of the Director

Source: (Gregersen and Brown 2019)

Figure 6.3.—Exploration wells in the Sale Area, 1959 to 2018.
3. Leases in the Sale Area

Factors contributing to the outcome of oil and gas lease sales in Alaska and the Sale Area include national and world economies, state fiscal terms, industry exploration budgets, oil and gas potential of the area, technological advances, the number of tracts available for lease, and the number of expired and relinquished tracts. An annual average of 488,864 acres of state lands have been leased for oil and gas exploration within the Sale Area since first issuance of the *North Slope Foothills Areawide Final Finding* in February 2001, however, no exploration wells have been drilled on these leases (Figure 6.4). An annual average of 751,619 acres of ASRC lands have been leased for oil and gas exploration within the Sale Area since 2001 (Figure 6.4), with 1 exploration well drilled in 2008/2009 (Chandler-1; Gregersen and Brown 2019). Active federal oil and gas leases occur adjacent to the Sale Area within the NPR-A near Umiat. In addition, BLM is planning the first Arctic National Wildlife Refuge (ANWR) Coastal Plain lease sale northeast of the Sale Area.

Known accumulations of oil and gas in the Sale Area occur on federal and ASRC lands near Umiat and Fortress Mountain (Figure 6.5), with the proportion of each within the Sale Area and listed in Table 6.1. There are currently no active state or ASRC leases and no oil and gas production from state or ASRC lands in the Sale Area.

![Figure 6.4.—Acres leased in the Sale Area, 2001 to 2020.](source: DO&G Oil and Gas Lease Inventories 2001 to 2020)
Figure 6.5.—Oil and gas accumulations, active leases, and infrastructure in the Sale Area.

Source: (Thomas et al. 2009)
C. Phases of Oil and Gas Development

There are several different phases of oil and gas activities: leasing, exploration, development, and production. While not all post-disposal oil and gas activities are routine, there are some oil and gas activities that are reasonably expected because they are commonly undertaken regardless of the project. Routine oil and gas activities include seismic surveys, drilling, construction of facilities and pipelines, and production.

Oil and gas activities include those direct and indirect activities that have occurred in the past, are presently occurring, or are likely to occur in the future. Petroleum-related activities include such major undertakings as conducting seismic operations, constructing roads and trails for transporting equipment and supplies, drilling exploration and delineation wells, constructing gravel pads and roads, drilling production and service wells, installing pipelines, and constructing oil and gas processing facilities. End of field-life stages may include decommissioning infrastructure, any necessary clean-up, and returning the land back to acceptable conditions. The activities likely to have the greatest effects vary by resource.

Common industrial facilities associated with the oil and gas industry in the Sale Area include: drill sites, well pads, ice pads, production pads and injection pads, platforms, artificial islands and causeways, wells (such as exploratory, development, production and waste disposal), processing facilities, facility oil piping, crude oil and natural gas transmission pipelines, flow lines and pipelines, maintenance complex, emergency response center, gravel roads, ice roads, airports, bridges, power plants, refineries, and residential centers.

1. Disposal Phase

Oil and gas lease sales are the first step in developing the state’s oil and gas resources. Annually, the Alaska Department of Natural Resources (DNR) prepares and presents a 5-year program of proposed oil and gas lease sales to the Alaska Legislature. Currently, the DNR’s Division of Oil and Gas (DO&G) conducts competitive annual lease sales, offering for lease all available state acreage within five areawide lease sale areas (North Slope, Beaufort Sea, Cook Inlet, North Slope Foothills, and Alaska Peninsula). Each lease sale area is divided into tracts and interested parties that qualify to hold an interest in leases may bid on one or more tracts.

Companies and individuals interested in bidding on state oil and gas leases may conduct extensive evaluations on the resources and economics of certain areas. Data is available from public sources (DNR and Alaska Oil and Gas Conservation Commission [AOGCC]) consisting of well log data, tax credit seismic surveys, well core data, publications, and geologic maps among other resources. Economic analysis is also critical in determining whether to bid on acreage and what amount to bid. Companies also may conduct seismic surveys without a lease to assist in evaluating leasable areas.

Alaska has several leasing methods to encourage oil and gas exploration and maximize state revenue. These methods include combinations of fixed and variable bonus bids, royalty shares, and net profit shares. For the past 20 years the state has offered leases at sealed bid auction, cash bonus bidding, with fixed royalty rates. The cash bonus bid variable is a per-acre dollar amount. After a bid is received on a tract, DO&G verifies the state’s ownership interest and acres available for lease within the tracts. Only those state-owned lands within the tracts that are determined to be free and clear of title conflicts that are not subject to another lease are available to lease. The state may accept bids online. Upon lease issuance, the bidder will become a lessee with rights and obligations of a lease agreement passing to the company or individual. A lease grants a lessee the exclusive right to use the leased areas for oil and gas exploration, development, and production activities.
only; it does not authorize other operations or any additional specific activities to be conducted on the lease.

2. Exploration Phase

During the exploration phase, information is gathered about the petroleum potential of an area by examining surface geology, researching data from existing wells, performing environmental assessments, conducting geophysical surveys, and drilling exploratory wells. Surface analysis includes the study of surface topography or the natural surface features of the area, near-surface structures revealed by examining and mapping exposed rock layers, and geographic features such as hills, mountains, and valleys. Geophysical exploration and exploration drilling are the primary activities that could result in potential effects to the Sale Area. Geophysical surveys, primarily seismic, help reveal what the subsurface may look like. Geophysical exploration of the Sale Area has occurred since prospectors discovered oil seeps in the 20th century.

A lease plan of operations must be approved before any operations may be undertaken on or in a leased area, except for activities that would not require a land use permit or for operations undertaken under an approved unit plan of operations.

3. Development and Production Phase

The development and production phases are interrelated and overlap in time; therefore, this section discusses them together. During the development phase, operators evaluate the results of exploratory activities and develop plans to maximize recovery of hydrocarbons from a reservoir. Common activities include drilling development and waste disposal wells, construction of roads and pads, and installation of pipelines and production facilities. Delineation and development drilling occur after initial discovery of hydrocarbons in a reservoir, and additional wells are often drilled after production begins.

The production phase is the process of bringing well fluids to the surface and transporting them to a processing facility. Pipeline systems and processing facilities are built, and transportation of oil and natural gas begins during this phase. The final project parameters will depend on the surface location, size, depth, and geology of a specific commercial discovery.

A central processing facility usually serves as the operational center for long-term production activities in a large oil or gas field. The central processing facility typically is located on the largest and most central, or initial, development location. Equipment at the central processing plant is used to separate the fluids that are produced from the wells (oil, natural gas, and water) to sales quality oil and re-injection in the case of water or excess gas. Often, the same central processing facility will process oil, water, and gas from nearby satellite reservoirs that are too small to justify a separate facility. Produced oil is filtered to remove sand and processed to remove water and gas before being piped through a sales meter and into the sales-oil pipeline system and eventually to a ship, which will transport sales oil to the nearest refinery. Associated gas is usually processed to remove liquids and impurities, compressed, and reinjected into the reservoir through gas injection wells or sent through a pipeline to another field or area for enhancing oil recovery or used as fuel gas. In the case of a commercial, non-associated gas operation, gas is processed and sent through a compressor then directly into a gas pipeline to market. Water can be processed, chemically treated, and reinjected into the reservoir for pressure maintenance.
D. Post-Disposal Oil and Gas Activities

Oil and gas activities associated with the post-disposal phases include geotechnical and geophysical surveys; exploratory and development drilling operations; construction of pads, facilities, and other infrastructure; and production and transportation of oil and gas. It is reasonable to assume that some exploration drilling will occur on tracts leased in this sale within the initial term of the lease. However, whether exploration and development will occur in the Sale Area depend on several factors: 1) the subsurface geology of the area, 2) a company's exploration strategy, and 3) the projected price and demand for oil and gas. Geology dictates the extent of exploration. Several dry holes (no substantial hydrocarbons encountered) can discourage further exploration in an area. Whether a lessee proceeds with exploration of an area may depend on the area's priority when weighed against the lessee's other commitments. If exploration does occur in an area, and an accumulation is discovered, development and production will only proceed if the lessee can be assured an acceptable profit. Acceptable profits depend on the price of oil or gas, the lessee's development costs, and the cost of getting the oil or gas to market.

1. Seismic

Seismic survey work is an integral part of exploration for oil and gas fields. Seismic data is collected from surface-induced seismic pulse to image subsurface formations with sensors collecting the data as seismic shock waves bounce off formations. The shock waves are created along predetermined lines using air-guns in open water, and vibrator trucks or small explosives on land and landfast ice. Seismic surveys are typically conducted in two-dimension (2D) or three-dimension (3D) surveys. Both survey types are useful for evaluating a prospect.

Seismic may be used during all phases of oil and gas development, including pre-disposal, to locate and produce oil and gas from new and existing developments. Companies may elect to license existing data and reprocess the data without conducting a seismic survey. Other companies may acquire data through commissioning their own program. It is also common for seismic contractors to conduct their own seismic surveys on unleased land or on behalf of a lessee. Geophysical exploration by means of seismic surveys informs the analysis of a play, where a company will conduct exploratory drilling, further mapping of a producing field, and evaluating new intervals throughout the development process.

Seismic data has been collected in the Sale Area for decades. Continuing acquisition of seismic data is undertaken to capture higher resolution data through finer seismic grid spacing or grid pattern, and to acquire additional seismic data using advanced techniques over an existing discovery. Reflection seismic data are used to image the layering and geometries of the subsurface and detect changes of lithology and fluid properties. These images, when combined with current well information, can be used to better image and define the limits of the discovered hydrocarbon pool, and help design efficient development drilling and enhance the ability to successfully identify high-grade drilling targets.

Several advanced seismic techniques can be used to image producing fields. Lands already in production are sometimes subjected to repeated 3D seismic surveys to monitor changing reservoir properties resulting from production. This seismic technique is sometimes called four-dimension (4D) seismic because the repetition adds the dimension of time to the surveys. This technique can also use permanent static geophones to ensure repeatability and coupling. Additional geophysical techniques can be used to gather information specifically about very near surface geology, usually to identify drilling hazards. They include high-resolution shallow seismic, side-scan sonar, fathometer recordings, and shallow coring programs. High-resolution shallow seismic surveys are specifically designed to image the bottom of a water body and very shallow geology. They employ
a lower energy seismic source and a shorter cable than surveys targeting deeper oil and gas potential (US Senate 2011).

Collection of seismic reflection data in aquatic areas (ocean, lakes, bays, and lagoons) is commonly accomplished using vessels of varying size during ice-free periods. Typically, one or more air guns are used as a sound source. Air guns, which are deployed behind the seismic vessel, generate a seismic signal by creating a sharp air bubble pulse in the water at intervals about once every 10 seconds. Marine receivers are composed of piezoelectric hydrophones that are contained in long, sealed tubes. Receiver systems can be deployed either as streamers that are towed behind a vessel or as cables that are laid directly on the seabed or lake bottom. Seismic streamers can be several miles in length and are generally used in deeper water where maneuverability is not an issue. Seismic cables (on-bottom cables) or nodal cableless systems are used in shallower water or in waterbodies where ice has not reached the bottom. Both receiver systems contain numerous hydrophones that measure faint pressure signals returning from reflections in the subsurface. These seismic data acquisition techniques are generally intended for imaging subsurface depths of several hundred feet to 6 miles. Surveys designed for shallower subsurface depths and higher resolution generally employ lower sound levels and shorter hydrophone systems (Asseev et al. 2016).

When a lessee or contractor seeks a permit to perform a seismic survey of any variety in the Sale Area, a miscellaneous land use permit (MLUP) is required through DNR. Seismic surveys can be performed at any phase of oil and gas development regardless of whether a party holds interest in the subject leases. Through the MLUP review, DNR will evaluate the project plan and consider other agencies’ input and authorities to assess potential impacts of the project. Potential project impacts are mitigated through mitigation measures and, possibly, lease stipulations.

2. Drilling

Before initiating any drilling, a lease plan of operation application must be submitted to DNR for review and approval. The application is reviewed for legal compliance by DNR and other state, federal, and local government entities. DNR evaluates foreseeable effects of the proposed application operations, assesses compliance with lease mitigation measures, and determines the need for lease stipulations to protect resources and the best interest of the state. An application may require conditions for approval before final approval of a plan of operations. All exploratory, delineation, and development well drilling is subject to plan of operation approval. Proposed wells within units must also be documented and approved through a plan of exploration or development with DO&G before drilling operations may be conducted. Other agencies also issue authorizations for drilling of wells and/or activities associated with drilling.

a. Exploratory Drilling

Exploratory drilling often occurs after seismic surveys are conducted, and when the interpretation of the seismic data incorporated with all available geologic data reveals oil and gas prospects. Drilling, which proceeds only after obtaining the appropriate permits, is the only way to determine whether a prospect contains commercial quantities of oil or gas, and aids in determining whether to proceed to the development phase. Drilling operations collect well logs, core samples, cuttings, and a variety of other data. A well log is a record of one or more physical measurements as a function of depth in a borehole and is achieved by lowering measuring instruments into the well bore. Well logs can also be recorded while drilling. Cores may be cut at various intervals so that geologists and engineers can examine the sequences of rock that are being drilled (Chaudhuri 2011).

The drill site is selected to provide access to the prospect and, if possible, is located to minimize surface area disturbance. Sometimes temporary roads must be built to the area. Non-permanent roads are constructed of ice, with permanent roads being constructed of sand and gravel placed on a
liner above undisturbed ground. Construction of support facilities such as production pads, roads, and pipelines may be required. A typical drill pad is made of ice or sand and gravel placed over a liner. The pad supports the drill rig, which is brought in and assembled at the site, a fuel storage area if necessary, and a camp for workers. If possible, an operator will use nearby existing facilities to house its crew. If crew facilities are not available, a temporary camp may be placed on the pad (Chaudhuri 2011).

To define the limits of reservoirs after a discovery is made, several delineation wells may be drilled before making a commitment to full project development. Additional delineation wells surrounding the discovery well would likely be planned for the following winter seasons and would require new ice pads. Delineation-well drilling would be coordinated with any existing 3D seismic surveys (Duplantis 2016). Upon making a discovery and sufficiently delineating a reservoir, production of the resource and development of the field will take place.

b. Production Drilling

Production or development drilling will be conducted from gravel pads with several wells typically drilled from that pad depending on development plans for the field. The production drilling process is like exploration drilling in that drilling fluid is used to balance pressure to prevent blow-outs, remove rock fragment, and cool the drill bit. During the process of drilling the well, well casing is placed in the hole for stabilization and to prevent caving. Once drilling is completed, testing is conducted to determine where to perforate zones and begin stimulation of those zones to enhance flow rates. Production tubing is installed in the well to carry liquids and gas to the surface and a “Christmas tree” is installed at the surface to control flow to or from the well depending on whether the well is an injector or a producer. This process occurs for each well.

Directional drilling is used to extend the length of the reservoir that is penetrated by the well (US Senate 2011). Directional drilling technology enables the driller to steer the drill stem and bit to a desired bottom-hole location, sometimes miles away from the surface location of the rig, or to a specific depth zone within a reservoir. Directional wells initially are drilled straight down to a predetermined depth and then gradually curved at one or more different points to penetrate one or more given target reservoirs (Duplantis 2016). Directional drilling allows multiple production and injection wells to be drilled from a single surface location such as a gravel pad or offshore production platform, thus minimizing cost and the surface impact of oil and gas drilling, production, and transportation facilities. It can also be used to reach a target located beneath an environmentally sensitive area and may offer the most economical way to develop offshore oil fields from onshore facilities. Extended reach drilling is used to access reservoirs that are remote, up to 6 miles, from the drilling location. These techniques allow for drilling into reservoirs where it is not possible to place the drilling rig over the reservoir (US Senate 2011).

In addition to production wells, other wells are drilled to inject water or gas into the field to maximize oil recovery. These wells generally are referred to as service, or injection, wells. Numerous injection wells are required for waterflood programs, which are used routinely throughout the production cycle to maintain reservoir pressure. Application of horizontal well technology can reduce the number of production wells required to drain a pool and reduce the number of drilling pads and their sizes (US Senate 2011).

c. Drilling and Production Discharges

Drilling and production discharges include drilling fluids, production chemicals, and injection chemicals.
i. Drilling Fluids

Drilling fluids are necessary for most new well drilling operations. They provide a barrier for well control, help to remove cuttings from the well bore as they are produced, maintain pressure on the formation, and maintain formation stability among other functions (IPIECA 2009). The AOGCC requires drilling fluid systems to meet its requirements unless it determines otherwise (20 AAC 25.033).

Once a rig is in place and drilling has begun, waste discharges could include drill cuttings, spent drilling fluids, cuttings from water-based well intervals, domestic wastewater, excess cement, brine water from desalination units, uncontaminated deck drainage, and blowout preventer fluid (UNEP IE 1997). However, Section 402(a) of the Clean Water Act prohibits the discharge of produced water and drilling wastes into the marine environment from oil and gas production facilities that are either onshore or in coastal waters. On the North Slope, nearly all exploration and production wastes are injected into underground waste wells (Veil 2001). Generally, all wastewater, spent fluids, and chemicals would be disposed of in injection wells approved by the US Environmental Protection Agency (EPA), the AOGCC, or Alaska Department of Environmental Conservation (ADEC), depending upon waste characterization.

Rock cuttings, broken bits for solid material removed from a borehole during drilling, are typically trucked to one of several North Slope grind-and-inject facilities. For some operations, solid waste disposal sites are authorized near drilling sites by ADEC for short-term waste storage before being transported for disposal.

ii. Produced Water

Produced water is water that comes from an oil and gas reservoir to the surface through a production well with hydrocarbons. It is the largest waste stream of conventional oil and gas wells. The produced water volume increases over the economic lifetime of a producing field and may be up to 95 percent of the total volume produced by the end of the field’s production history. Produced water contains formation water, injection water, and other chemical additives such as hydrate inhibitors, emulsion breakers, flocculants, coagulants, defoaming agents, scale and corrosion inhibitors bactericides and other substances (AMAP 2010).

Produced water on the North Slope is reinjected into reservoirs for waterflooding and pressure maintenance or injected through wastewater injection wells to shallow reservoirs. As a field matures, measures are taken to treat produced water before reinjection into the reservoir to eliminate bacteria and chemical additives. When produced water can no longer be treated and reinjected, the alternative in the Sale Area is disposal. The ADEC and AOGCC authorize disposal of produced water. More information can be found in Chapter Seven outlining government authorities to regulate wastewater disposal and produced water injection.

3. Road and Facility Construction

i. Facilities

After a commercial discovery of oil or gas has been confirmed by delineation wells and seismic surveys, several construction activities are required to develop a permanent production operation. A production operation complex would, at a minimum, contain a production pad that could potentially support dozens of wells and contain a large central processing facility for an oil field or a combined central processing and gas compressor facility. In addition, a production complex typically would include an airstrip, helipad, camp facilities, and storage yard. The production operation also would include feeder lines, regional pipelines, a booster pump for oil or additional compression stations
for gas, a high-pressure gas trunk line, a gas conditioning facility, and an oil-sale pipeline to transport the resource to market (NRC 2003).

Depending on the size and location of the field or the presence of nearby fields, the production operation complex may also include outlying oil production pads. The smaller satellite pads would serve primarily as a well pad designed to produce hydrocarbons from a smaller prospect located beyond the reach of wells drilled from the main production pad or central processing facility. A gathering system to the central processing facility or central processing or gas compressor facility, and a road, or in some cases an airstrip instead of a road, would be needed to access the satellite pad (NRC 2003).

Like drilling operations, all construction activities on a lease are subject to a plan of operations approval by the DNR and may require consultation with ADEC if there are institutional controls established for previous spills that may limit ground disturbing activities. The construction or maintenance of major production facilities also require plans of exploration or development.

**ii. Roads**

Development and operation of oil and gas facilities in the Sale Area may require access across the tundra, off pads, or on gravel or ice roads. Such access could be necessary to respond to spills or other emergencies; conduct training to respond to potential spills; conduct pipeline inspection, maintenance, and repair; facilitate ice road construction; or transport equipment and supplies to oil developments not connected to the interconnected North Slope gravel road network. Vehicles would conduct these activities from the nearest production or processing facility pads or gravel or ice roads (NRC 2003).

Construction of ice roads across tundra begins by compacting snow with wheeled front-end loaders and water trucks. If prepacking is authorized, it is done with low-ground-pressure vehicles or various tracked rigs. Typically, ice roads are designed to be a minimum of 6 inches thick and 25 to 35 feet wide and can be several miles long. New ice-road construction methods, such as using aggregate chips shaved from frozen lakes, substantially decrease both water demand and construction time. For example, under good (very cold) conditions, an ice-road-buildup rate using only liquid water is 1.5 inches per day, whereas using aggregate chips could increase the buildup rate to 4.5 inches per day, with equivalent reduction in the volume of water required. Similar flooding and composite (aggregate chip) methods are employed to construct ice bridges over rivers and lakes. Floating ice bridges are used to cross deep rivers, such as the Colville River (NRC 2003).

Snow-packed trails are also constructed and approved for use by low-ground-pressure vehicles and can be used for moving equipment, supplies, personnel accommodations, and drill rigs capable of disassembly to components small enough for transport on such vehicles. When the tundra is open for prepacking, two vehicles with the least amount of ground pressure (1.2 to 2.0 pounds per square inch [psi]) are run side-by-side and follow geographic positioning system (GPS) coordinates along the entire length of the approved snow trail route. After several days of snow capture along the new trail, these vehicles drive the route again to complete the snow compaction process and open the trail for use by other low-ground-pressure vehicles that exert less than 4 psi of pressure on the ground. Due to winter-travel time constraints, costs, and potential extensive distances from current infrastructure such as the Dalton Highway to new exploration areas, frequency in the construction and use of snow-packed trails is expected to increase (NRC 2003).

For the most part, authorizations relating to road construction for temporary use (ice roads and snow-packed trails) are issued through land use permits by DNR’s Division of Mining Land and Water (DMLW). The only exception is temporary use roads for seismic surveys will be authorized through a MLUP issued by DNR’s DO&G. DO&G issues MLUPs for seismic survey activities within proposed seismic survey boundaries which includes temporary use roads. Portions of
temporary roads that fall outside of the seismic survey boundaries would be issued by DMLW. DO&G will authorize permanent roads (gravel) on leases in the Sale Area through a plan of operations or an easement (AS 38.05.850) for proposed permanent gravel roads on state-owned surface land within an oil and gas lease, unit, or the Sale Area. These authorizations evaluate potential impacts and seek agency review to address and mitigate potential impacts from construction and operation.

E. Methods to Transport Oil and Gas from the Sale Area

The transportation and distribution of petroleum products and natural gas from oil fields to refining and processing plants requires a comprehensive transportation system. Strategies for transportation depend on multiple factors, most of which are unique to an individual discovery. The location and nature of the oil or gas deposits determines the type and extent of facilities necessary to develop and transport the resource. DNR and other federal, state, and local agencies will review the specific transportation system when it is proposed. Oil and gas transportation systems may include pipelines, marine oil and liquid natural gas (LNG) terminals, distribution hubs, tank farms, tanker vessels, LNG carriers, tank trucks, and rail tank cars. The following discussion is a general overview of the methods most likely to be used to transport oil or gas from the Sale Area; these include pipelines and tanker vessels.

1. Existing Transportation Systems

Existing operations use in-field gathering pipelines or flowlines to bring the oil mixed with water and gas from individual wells to processing facilities. Sales quality crude oil is transported from processing facilities through central transmission pipelines that converge at Pump Station 1 where oil is delivered to TAPS. Oil produced from the North Slope is then transported to market via TAPS, which is the regional oil transportation system for North Slope oil fields that was established in 1977. TAPS is a 48-inch diameter pipeline that runs about 800 miles from Prudhoe Bay to the ice-free Port of Valdez and is operated and monitored by Alyeska Pipeline Service Company (Alyeska). From the storage and marine loading terminal at Valdez, oil is loaded onto tankers and transported to United States and foreign markets.

The throughput capacity of TAPS plays a significant role in North Slope development. The historic maximum daily throughput capacity of TAPS was over 2.1 million barrels per day (achieved in 1988). Since this peak, throughput has declined steadily reaching an average daily throughput of 999,000 barrels per day in 2000, and 480,000 barrels per day in 2020 (Figure 6.6). In its current configuration, with 4 of 10 pump stations in operation, the maximum TAPS throughput rate is 1.14 million barrels per day, although drag reducing agents are required at rates exceeding 750,000 barrels per day (Alyeska Pipeline Service Company 2016). With less oil being delivered to TAPS, flow rates are lower, transit times are longer, and oil cools as it leaves the North Slope. Cooling leads to water separation, potential ice formation, and additional wax accumulation in the pipeline. With mitigation through adding heat at key locations along the pipeline, using freeze depressants and corrosion inhibitors, and managing wax deposits through pig design and additional wax management facilities, TAPS can likely continue to be operated safely and with reasonably high operational confidence down to throughputs of about 200,000 barrels per day (Alyeska Pipeline Service Company 2018). While these rates may be technically feasible, the increased transportation costs at this level of throughput may become uneconomic.

DO&G anticipates that future commercial oil discoveries in the Sale Area will use in-field gathering lines to bring crude oil to process facilities and central transmission pipelines from processing facilities for delivery to TAPS and transport to market. Currently, there is no regional
transportation system for natural gas from the North Slope equivalent to TAPS. Gas produced with oil from North Slope oilfields is either reinjected into reservoirs, used as fuel gas, or flared. Gas is transported within the North Slope by pipelines to other fields, TAPS pump stations, and to the village of Nuiqsut.

![Graph of Trans Alaska Pipeline System throughput, startup to 2020.](image)

Source: (Alyeska Pipeline Service Company 2021)

**Figure 6.6.—Trans Alaska Pipeline System throughput, startup to 2020.**

### 2. Oil Pipelines

The most likely method of transporting oil from the Sale Area is by pipeline. A pipeline, or pipeline facility, is defined as all the components of a total system used to transport crude oil, natural gas, or products for delivery, storage, or further transportation (AS 38.35.230). Pipelines may be either buried or elevated.

Transportation pipelines from fields, may be connected, or tied-in to TAPS for oil transport, via new or existing pipelines. These are either elevated or buried depending on several factors such as the substance being transported, the local soil and ice conditions and other considerations such as movement of wildlife. An individual pipeline may alternate between buried and elevated, as is the case with TAPS. The advantages and disadvantages of the two options are set forth below. The mode of transportation from a discovery is an important factor in determining whether it can be economically produced. The more expensive a given transportation option, the larger a discovery will have to be for economic viability.

#### a. Elevated Pipelines

Elevated pipelines are typically used in North Slope oil field development to prevent heat transfer from hot oil in the pipelines to frozen soils, since heat would degrade the permafrost (DeGeer and
Elevated pipelines are placed on crossbeams mounted between pairs of vertical support members (VSM). Low above-ground pipelines can restrict wildlife movements unless provisions are made to allow for unimpeded passage. The current pipeline construction mitigation measures require that pipelines be elevated 7 feet above the ground surface except where the pipeline intersects a road, pad, or where ramps are installed to facilitate passage.

Pipeline routes are typically laid out in straight-line segments (or alignments) and are installed aboveground on VSMs. In cold weather locations, pipelines typically have expansion loops as part of the typical layout to allow for pipe expansion and contraction in extreme weather conditions. On the North Slope, elevated installation method is preferred over buried pipelines, because aboveground pipelines take less time to construct, cause less disruption to permafrost and sensitive environments during installation, are easier to monitor and repair, provide more flexibility for later modifications such as adding new pipelines, and heat transfer to thaw unstable soils is minimized. Pipeline clearance is generally higher (up to 20 feet) over topographic lows (stream valleys), because engineering requirements call for a nearly level pipeline route. Small, shallow lakes could be crossed by elevated VSMs, whereas large or deep lakes would have pipeline VSMs routed around their shorelines with some setback. Pipelines crossing large rivers, such as the Colville River, could be on bridges or buried using horizontal directional drilling techniques. Elevated pipelines would likely cross narrow streams on suspension spans to minimize impacts to streambanks and riparian vegetation and to avoid potential problems associated with corrosion, maintenance, ice jams, and abandonment of buried pipelines.

Elevated pipelines offer more ways to monitor the pipeline including ground-based visual inspections, visual air inspections, ground-based infrared and airborne forward-looking infrared surveys (FLIR). In-line inspection (ILI) using pigging methods can be used for both aboveground and belowground pipelines but is the only practical method for thoroughly inspecting belowground installations (SPCS 2014).

b. Buried Pipelines

Buried pipelines may be feasible in the Arctic provided that the integrity of the frozen soils is maintained. However, there are some important considerations regarding long sections of buried pipe. First is cost, which depends on length, topography, soils, and distance from a gravel source to the pipeline. Second, a buried pipe is more difficult to monitor and maintain than elevated pipelines, although recent technological advances in leak detection systems have significantly increased the level of confidence for pipeline surveillance capabilities. These systems are described under the oil spill prevention subsection in this chapter. Third, buried pipelines may contribute to increased loss of wetlands because of gravel fill. Finally, buried pipelines are sometimes not feasible from an engineering standpoint because of the thermal stability of fill and underlying substrate (DeGeer and Nessim 2008; Wen et al. 2010).

3. Natural Gas Transportation

Unlike oil, gas is difficult to store due to its physical nature. Gas needs high pressures and low temperatures to increase the bulk density and generally needs to be transported to its destination shortly after production from a reservoir (Mokhatab et al. 2006; Mokhatab et al. 2019). Since North Slope gas cannot presently be transported to market, gas produced on the North Slope is mostly used for local facility fuel and reservoir management purposes. Pipelines are used to transport natural gas between fields to augment operations or to local communities for heating fuel.

Trucking North Slope natural gas to markets within Alaska has been evaluated by the Interior Energy Project but would require construction of an LNG plant on the North Slope. Trucking was considered feasible because hauling LNG is a well-established practice with a strong safety and
reliability record and because more than 100 trucks per day presently carry diesel and other products between Deadhorse and Fairbanks during the winter months. To supply LNG to Fairbanks during the peak winter demand period, an estimated 28 round trips (1,017 miles per trip) per day for the 10,500-gallon LNG trailers would be required (AIDEA and AEA 2013).

The Alaska Gasline Development Corporation (AGDC) is pursuing two options to bring natural gas from North Slope fields to foreign and domestic markets. The Alaska Liquid Natural Gas (Alaska LNG) project, AGDC’s primary project, is an 800-mile pipeline system to bring natural gas from the North Slope to local communities at select offtake points and a liquefaction plant in Nikiski for loading on marine vessels (LNG carriers). Natural gas from the Point Thomson and Prudhoe Bay fields would be transported to a gas treatment plant near Prudhoe Bay where sales quality gas would be produced for shipment at a rate of 3.3 billion standard cubic feet per day along a 42-inch diameter pipeline to Nikiski in Cook Inlet (AGDC 2020). The Alaska Stand Alone Pipeline (ASAP) project is a backup project to provide reliable, affordable energy to residents of Alaska that includes a 733-mile low pressure pipeline from Prudhoe Bay to an ENSTAR pipeline north of Wasilla, and a 30-mile lateral pipeline between the main pipeline and Fairbanks (AGDC 2018b).

a. Natural Gas Pipelines

Bringing natural gas from producing regions to markets requires a transportation system. Pipelines may follow elevated or buried routes, depending upon the engineering requirements needed and the soils found in the field. Natural gas may require treatment to remove impurities and to prepare it for transport. Treatment may include depressurization and dehydration. To keep the gas flowing along the pipeline route, the gas may also undergo pressurization by compressors and liquid separation treatment along the length of the pipeline. Pigging facilities and metering stations are constructed along the pipeline to monitor and manage the gas. Central control stations manage information along the pipeline to allow for quick prevention and necessary reaction to problems (Mokhatab et al. 2006; Mokhatab et al. 2019).

Currently, there are five natural gas pipelines operating on the North Slope (SPCS 2014). Alyeska operates a fuel gas line (FGL) from the North Slope fields to pump stations north of the Brooks Range (Pump Stations 1, 2, 3, and 4; Alyeska Pipeline Service Company 2016). The FGL generally runs parallel to the TAPS and is predominantly buried. Harvest Alaska, LLC, operates a 10-inch diameter, 16-mile-long natural gas pipeline between the Prudhoe Bay central compressor plant and Northstar Island where the gas is used to maintain reservoir pressure. While offshore portions are buried subsea, onshore this gas pipeline is elevated and co-located on VSMs with the Northstar Oil Pipeline. The North Slope Borough (NSB) is responsible for the Nuiqsut Natural Gas Pipeline (NNGP) which transports natural gas from the Alpine production pad to the village of Nuiqsut. The NNGP, at just over 14 miles long, is elevated for almost 9 miles as it leaves the Alpine Production Facility, and is buried for about 5.6 miles in tundra and under the Nuechelik Channel (SPCS 2014).

Elevated gas pipelines protect permafrost and allow for ease of inspection, maintenance response upon leak detection, and are generally less expensive to construct. Elevated pipelines must be designed and constructed to allow free movement of wildlife. Burial of natural gas pipelines can be desirable for both safety and operational reasons. High-pressure gas lines pose a risk of rupture and explosion. Burial and offset from adjacent oil pipelines mitigate the potential impacts if a gas explosion were to occur. High-pressure gas lines operate more efficiently when chilled, and permafrost is a good material in which to install dense-phase, high pressure gas pipelines that contain natural gas liquids. In designing buried pipelines for use in the Arctic, it is important to consider large deformations that could occur from frost heave, thaw settlement, and slope movement (DeGeer and Nessim 2008). The 10-inch FGL buried from Pump Station 1 to Pump
Station 4 has required significant modifications to continue proper functioning because of thaw settlement and frost heave.

4. Advantages of Pipelines for Transporting Oil and Gas

Pipelines have been essential for gathering and transporting hydrocarbons on the North Slope since the first well was put into production. Once the TAPS was completed in 1977, this critical piece of Alaska oil and gas infrastructure allowed North Slope oil to be commercialized (Appert and Favennec 2005). Given the lack of roads and deep-water harbor on the North Slope, pipelines have been essential for the development and commercialization of Alaska’s crude oil. The only road from the rail belt of Alaska to the North Slope is the Dalton Highway, which was developed for construction of TAPS. At the time of permitting TAPS, alternatives like rail or highway trucking were considered; however, given the cost of construction and comparatively low costs of operations along with the lower rate of pipeline incidents compared to trucks and railcar incidents, the pipeline was selected as the most reasonable method of transportation. This is still true today.

The development of TAPS has allowed main transmission pipelines to be developed above ground on the North Slope to the east, west, and north. These pipelines serve as vital components of commercializing North Slope reserves. Without the development of pipelines, additional gravel roads for trucks or gravel beds for railroads would have been required that would create a patchworked and segregated landscape of more intrusive infrastructure with more ground and wetland disturbance. Gravel roadbeds interrupt surface water flow, are susceptible to spring flooding, are costly to construct, and require constant maintenance. By comparison, once an elevated pipeline is constructed on VSMs it requires very little maintenance and causes little or no ground disturbance. Wetland and upland crossed by elevated pipelines retain their vegetation cover and the uninterrupted surface contours allow unimpeded surface water flow.

Pipeline monitoring on the North Slope is now done mainly by using remote instrumentation with ILIs, and in some cases using smart pigs and maintenance pigs. Numerous monitoring and safety systems are installed to provide redundancy in these electrical and mechanical safety systems. In addition to mechanical shutoff valves, vertical expansion loops can provide a fail-safe method of controlling pipeline pressures and leaks.

Transportation of natural gas in the Sale Area is mainly performed through gathering lines bringing raw materials from wellheads to processing facilities and then pipelines back to well pads for reinjection into a reservoir. The incidents of accidents from transportation of natural gas via gathering lines is historically very low. Data provided by Pipeline and Hazardous Materials Safety Administration (PHMSA) shows what types of pipeline systems are most susceptible to accidents. Over the course of the period from 1992 to 2011, PHMSA data shows far fewer incidents from gathering lines than transmission and distribution lines. The data further shows trucking and rail incidents far exceed the incident rates of natural gas pipelines (Furchtgott-Roth 2013). Additional advantages of transporting natural gas through pipelines is the reduced cost, expanding the development of lower emission fuel, and a faster, more dependable delivery to markets.

5. Disadvantages of Pipelines for Transporting Oil and Gas

The most distinct disadvantage of pipelines is their high up-front investment for construction costs. Pipeline projects on the North Slope have traditionally been built on VSMs due to the permafrost and shallow water table. The addition of raw materials used for construction, especially for elevated pipelines, adds to the costs of pipeline development in the North Slope when compared to more temperate climates in the Lower 48.
Additional considerations for pipeline operators are the challenges of preserving the quality of crude oil along with maintenance of the pipe. The larger the pipeline, like TAPS, the more the cold weather challenges are manifested, and the more operational costs are shifted to address these issues. The cold weather challenges are exacerbated by fluctuations in throughput. While the daily throughput of TAPS in a year can vary depending on maintenance and season, the overall decline in throughput has introduced new challenges to the large diameter pipe such as wax build-up and potential icing in cold temperatures.

When transporting oil by pipeline, many chemicals are added to the oil to improve the rate and efficiency of throughput and to protect the pipeline. After extraction, oil cools from reservoir temperature and heavy fractions such as wax form crystals. Several deposits of wax may plug both pipelines and production facilities. To remove deposits of wax from the pipeline scraper pigs are used in combination with a wax inhibitor. Other chemicals are added to the oil stream such as corrosion inhibitors to prevent corrosion damage to the pipe. Other cold-weather risks such as ice formation, reduced pigging velocities, water dropout, and reduced accuracy in leak detection can negatively impact the operation of oil pipelines and be considered a disadvantage to transporting oil by pipeline (SPCS 2014).

The potential problems and risks associated with transportation of natural gas through pipelines are typically addressed in mitigation measures and lease stipulations. A major risk of transporting gas through a pipeline is a leak or explosion. The measures and methods employed to prevent leaks or explosion, including line integrity protection, pipeline monitoring, and in-line inspections, are detailed in the Spill and Release section.

6. Tanker Vessels and Marine Terminals

Presently, vessels are not considered a method likely to be used to transport oil from the North Slope or the Sale Area. Tankers are currently used in Alaska to transport oil to and from Cook Inlet and from the Alyeska Terminal in Valdez, the terminus of TAPS to markets on the west coast of the United States and Asia. The use of tankers increases the risk of a large oil spill. The US Coast Guard (USCG) maintains a vessel traffic service in the Gulf of Alaska and Prince William Sound. Vessels are escorted through Prince William Sound. Two tugboats escort tankers from the Valdez terminal to Cape Hinchinbrook (Alyeska Pipeline Service Company 2016). Use of tugboats reduces the risk of grounding or collision and the spills associated with these incidents. Shallow waters, seasonal ice, and lack of a deep-water port, and TAPS mean tankers are not a likely method for transporting oil from the North Slope.

The decline in sea ice in a warmer arctic and advances in ice-breaking ships has increased the window of navigation for the Northern Sea Route across Arctic Russia from a 4-month period between summer and autumn to the ability to sail westwards year-round and eastwards from July to December. In 2016, the Northern Sea Route saw 19 full transits from the Atlantic to the Pacific (McGrath 2017). Similarly, vessel traffic through the Northwest Passage through the Beaufort Sea and across Arctic Canada, including a few tankers and LNG carriers, has increased in recent decades (Dawson et al. 2018; Murphy 2018). In 2017, 32 vessels including a tanker crossed through the Northwest passage compared to 18 vessels in 2016, and 16 vessels in 2015 (Murphy 2018). In Arctic Canada, the distance traveled by ships nearly tripled from 1990 to 2015 with the largest proportion of ship traffic from general cargo vessels supporting mining activities in Canada and government icebreakers. Tankers were documented transiting the Canadian Beaufort presumably crossing through the Alaskan Beaufort Sea beginning in 2006 to 2010 and continuing into 2011 to 2015 (Dawson et al. 2018). Shipping routes across the Arctic Ocean avoid the much longer transit using southern routes through the Panama or Suez canals. However, infrastructure to support...
shipping traffic along the Northwest Passage, such as deep-water ports, search and rescue capabilities, ice-breakers, and spill response vessels, is lacking (Murphy 2018).

Shrinking of the Arctic ice pack and the advent of ice-breaking LNG carriers have identified an opportunity for an LNG terminal offshore of Alaska’s North Slope oil fields. A 2018 analysis to determine the commercial and technical viability of a North Slope LNG alternative to the Alaska LNG project concluded that a North Slope LNG terminal was not commercially viable (AGDC 2018a). LNG carrier technology has advanced, however, and the current successful use of ice-breaking LNG carriers from the Russian Yamal Peninsula in the Arctic Ocean as well as the development of offsite construction and ocean transport of LNG facilities may increase the viability of this option. LNG carriers are highly regulated and safety systems are mandated by maritime law and insurers. As a result, LNG has been safely transported around the world by ship and truck for more than 50 years, with over 300 million tons of LNG delivered worldwide in 2019. A LNG facility could be built under controlled conditions in a shipyard and floated to an offshore location with water deep enough to allow loading of LNG carrier (Qilak LNG 2020a, b).

7. Mitigation Measures and Other Regulatory Protections

Any product ultimately produced from lease sale tracts will require transport to market; however, it is important to note that the decision to lease oil and gas resources does not authorize the transportation of any product. If oil or gas is found in commercial quantities and production is proposed, final decisions and authorizations on transportation will be made through the local, state, and federal permitting processes. Those processes will consider pipeline route, construction design, long-term integrity management plans, oil spill contingency planning, and other environmental safeguards and will involve public participation. The state has broad authority to withhold, restrict, and condition its approval of oil and gas transportation facilities. In addition, boroughs, municipalities, and the federal government have jurisdiction over various aspects of any transportation alternative as noted in Chapter Seven. Measures are included in this best interest finding to mitigate potential negative effects of transporting oil and gas (see Chapter Nine). Additional site-specific, project-specific mitigation, and other regulatory measures may be imposed as necessary if exploration and development take place.

F. Spill Risk, Prevention, and Response

Oil spills and natural gas releases can occur on pads within the Sale Area when exploration or development drilling is occurring. Spills and releases of an array of different petroleum products, industrial fluids, and hazardous materials can also occur during production and transportation on pads, between facilities, or during delivery. The risk of a spill exists any time crude oil or petroleum products, and other hazardous materials are handled.

AS 38.05.035(g)(1)(B)(vii) requires the director to consider and discuss lease stipulations and mitigation measures, including any measures to be included in the leases to prevent and mitigate releases of oil and hazardous substances and a discussion of the protections offered by these measures. Chapter Seven provides information on regulatory authorities for spill prevention and response, process for spill or release containment, cleanup, and response training. Chapter Nine includes mitigation measures related to the release of oil and hazardous substances developed after the director considered the risk of oil spills, methods for preventing spills, and techniques for responding to spills.
1. Regulation of Oil Spill Prevention and Response

a. Federal Statutes and Regulations

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. §9605), and §311(c)(2) of the Clean Water Act, as amended (33 U.S.C. §1321(c)(2)) require environmental protection from oil spills. CERCLA regulations contain the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR §300). Under these regulations, the responsible party must plan to prevent and immediately respond to oil and hazardous substance spills and be financially liable for any spill cleanup. If the pre-designated Federal On-Scene Coordinator (FOSC) determines that neither timely nor adequate response actions are being implemented, the federal government will respond to the spill, and then seek to recover cleanup costs from the responsible party.

The Oil Pollution Act of 1990 (OPA 90) requires the development of facility and tank vessel response plans and an area-level planning and coordination structure to coordinate federal, regional, and local government planning efforts with the industry. OPA 90 amended the Clean Water Act (§311(j)(4)), to establish area committees and area contingency plans as the primary components of the national response planning structure. In addition to human health and safety, these area committees have three primary responsibilities:

- Prepare an area contingency plan;
- Work with state and local officials on contingency planning and preplanning of joint response efforts, including procedures for mechanical recovery, dispersal, shoreline cleanup, protection of sensitive areas, and protection and rehabilitation of fisheries and wildlife; and,
- Work with state and local officials to expedite decisions for the use of dispersants and other mitigating substances and devices.

b. Alaska Statutes and Regulations

As discussed in Chapter Seven, ADEC is the agency responsible for implementing state oil spill response and planning regulations under AS 46.04.030, which specifies when an Oil Discharge Prevention and Contingency Plan (contingency plan or ODPCP) is required. Contingency plans must document how the operator will comply with both prevention and response requirements established in statute and regulation. Regulations in 18 AAC 75 establish prevention, operation, and maintenance requirements for oil exploration and production facilities, oilfield flowlines, aboveground oil storage tanks and pipeline facilities, crude oil transmission pipelines, oil terminal facilities, facility oil piping, secondary containment, crude and refined oil vessels and barges, nontank vessels over 400 gross tons, and railroad tank cars. They also establish prevention training and record keeping requirements. ADEC places great emphasis on oil spill prevention training. Response planning requirements are also established in 18 AAC 75. These regulations establish planning standards, plan content, approval criteria, as well as application and review procedures. Plan holders must demonstrate proof of financial responsibility to respond to damages for a spill cleanup (AS 46.04.040). These regulations also detail the amounts and type of proof of financial responsibility that are acceptable. Operations may not start without ADEC approval of submitted proof of financial responsibility.

Regardless of whether operations are required to have an approved contingency plan, any person that discharges oil or other hazardous substances to the land or water of the State is required to report the discharge and respond to the spill. If ADEC’s State On-Scene Coordinator determines that neither timely nor adequate response actions are being implemented for spills, then the state
government may take over management of the spill response, and ADEC will seek to recover cleanup costs from the responsible party.

Alaska Department of Fish and Game (ADF&G) and DNR support ADEC in these efforts by providing expertise and information in their review of contingency plans. The industry must have an ADEC approved oil discharge prevention and contingency plan before operations commence. The application and review process for a contingency plan typically takes 180 days. DNR reviews and provides comments to ADEC regarding the adequacy of industry contingency plans.

**c. Industry Contingency Plans**

Contingency plans for exploration and production facilities (18 AAC 75.425) must include a Response Action Plan, the Prevention Plan, Supplemental Information (such as, facility description and diagrams, oil storage tank capacity, petroleum transfer procedure protocols, and response equipment inventory), Best Available Technology Review, and the facility’s Response Planning Standard (the volume of a spill the contingency plan must address). Blowout Contingency Plans are required, in addition to the contingency plan. If development and production should occur, additional contingency plans or major amendments to the existing contingency plan must be approved for each new facility before beginning an activity as part of the permitting process. Any vessels transporting crude oil from the potential development area must also have an approved contingency plan.

AS 46.04.030 provides that unless an oil discharge prevention and contingency plan has been approved by ADEC and the operator is in compliance with the plan, no person may:

- Operate an oil terminal facility, a pipeline, or an exploration or production facility, a tank vessel, or an oil barge; or
- Permit the transfer of oil to or from a tank vessel or oil barge.

Parties with approved plans are required to have sufficient oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)).

Discharges of oil or hazardous substances must be reported to ADEC on a time schedule depending on the volume released, whether the release is to land or to water, and whether the release has been contained by a secondary containment or structure (18 AAC 75.300).

The discharge must be cleaned up to the satisfaction of ADEC, using methods approved by ADEC. ADEC will modify cleanup techniques or require additional cleanup techniques for the site as ADEC determines to be necessary to protect human health, safety, and welfare, and the environment (18 AAC 75.335(d)). ADF&G and DNR coordinate with ADEC regarding the adequacy of cleanup.

A contingency plan must describe the existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation (AS 46.04.030; 18 AAC 75.425(e)(2)(E)). A contingency plan and its preparation, application, approval, and demonstration of effectiveness require a major effort on the part of facility operators and plan holders. The contingency plan must include a response action plan, a prevention plan, and supplemental information to support the response plan (18 AAC 75.425).

**d. Financial Responsibility**

Holders of approved contingency plans must provide proof of financial ability to respond (AS 46.04.040). Financial responsibility may be demonstrated by one or a combination of self-
insurance, insurance, surety, guarantee, approved letter of credit, or other ADEC-approved proof of financial responsibility (AS 46.04.040(e)). Operators must provide proof of financial responsibility acceptable to ADEC and have Certificate of Approval before operations begin.

e. Government Contingency Plans

In accordance with AS 46.04.200, ADEC must prepare, annually review, and revise the statewide master oil and hazardous substance discharge prevention and contingency plan. The plan must identify and specify the responsibilities of state and federal agencies, municipalities, facility operators, and private parties whose property may be affected by an oil or hazardous substance discharge. The plan must incorporate the incident command system, identify actions to be taken to reduce the likelihood of occurrence of catastrophic oil discharges and significant discharges of oil and hazardous substances, and designate the locations of storage depots for spill response material, equipment, and personnel. In Alaska, this requirement is met by the joint federal-state Alaska Regional Contingency Plan (ARRT 2018)

ADEC must also prepare and annually review and revise a regional master oil and hazardous substance discharge prevention and contingency plan (AS 46.04.210). The regional master plans must contain the same elements and conditions as the state master plan but are applicable to a specific geographic area. In Alaska, there are four joint federal-state Area Contingency Plans (ACPs) that meet this requirement: Arctic and Western Alaska ACP, Alaska Inland Area ACP, Prince William Sound ACP, and Southeast Alaska ACP (ADEC 2020c). The Sale Area is covered by the Alaska Inland Area Contingency Plan (AKIAC 2018).

2. Spill History and Risk

Any time crude oil or petroleum products are handled or stored there is a risk that a spill might occur. Large oil spills associated with the exploration, development, production, storage, and transportation of crude oil may occur from well blowouts or pipeline or tanker accidents. Petroleum exploration and extraction activities may generate chronic low volume spills involving fuels, other petroleum products, and other hazardous substances associated with normal operation of drilling rigs, vehicles, and facilities for gathering, processing, loading, and storing of crude oil. Spills may also be associated with the transportation of refined oil products to provide fuel for generators, marine vessels, and other vehicles used in exploration and development activities. A worst-case oil discharge from an exploration facility, production facility, pipeline, or storage facility is constrained by the maximum tank or vessel storage capacity, or by a well’s ability to produce oil. Impacts from spills are influenced not only on the size of the discharge, but by the receiving environment. Even small spills into a particularly sensitive environment can be highly damaging.

Oil and gas infrastructure in the Sale Area includes 25 plugged and abandoned exploration wells and TAPS from MP 64 to MP 150, including Pump Stations 3 and 4. In addition, the Sale Area is crossed by the Dalton Highway, a key component for transporting fuel, hazardous and non-hazardous chemicals, and other equipment and supplies to and from the North Slope oil fields. Between July 1995 and August 24, 2020, there have been 245 reported spills within the Sale Area (Figure 6.7). During this period, most (95 percent) of the spills were non-crude oil and hazardous substances, with most of the spill volume from hazardous materials (92 percent). The leading causes of reported spills in the Sale Area was structural/mechanical failure (63 percent) followed by human error (16 percent). The largest single spills have been releases of halon for fire suppression at Pump Stations 3 and 4, followed by spills of drilling muds, and diesel fuel. An average of 9.4 spills per year have occurred over the 25 year period from 1995 to 2020, with an overall declining trend in the number of spills (ADEC 2020e).
ADEC commonly cites the primary causes of spills of crude oil by volume throughout Alaska as equipment failure (48 percent), leaks (28 percent), line failure (10 percent), unknown (6 percent), overfill (5 percent), and other (3 percent; ADEC 2020d). Spill and contaminated site locations within the Sale Area are shown on Figure 6.8. The three active contamination sites in the Sale Area are associated with a BLM legacy exploration well, historic Alyeska’s Happy Valley Camp, and TAPS Pump Station 4 (ADEC 2020a).
Figure 6.8.—Contaminated sites and spills in the Sale Area.

Source: (ADEC 2020a, e)
a. Drilling

The most dramatic form of spill can occur during a well blowout. A well blowout can take place when high pressure gas is encountered in the well and sufficient precautions, such as increasing the weight of the drilling mud, are not effective. The result is that oil, gas, or mud is suddenly and violently expelled from the wellbore, followed by uncontrolled flow from the well. Blowout preventers (BOPs), which immediately close off the open well to prevent or minimize any discharges, are required for all drilling and work-over rigs and are routinely inspected by the AOGCC (AS 46.04.030) to prevent such occurrences.

Blowouts are extremely rare in Alaska and their numbers decline as technology, experience, and regulations influence drilling practices. There have been 11 blowouts on the North Slope, one with a release of oil in 1950 (AOGCC 2019a). The AOGCC regulations set forth a comprehensive well permitting process and rigorous well operations inspection program. It also has a program to minimize the likelihood of well failures or blowouts. Drilling plans and procedures are scrutinized to assess potential problems within rock formations and the drilling fluids used to control downhole pressure. Well construction is evaluated, and rigs are inspected before permission to drill is granted. New application of seismic data, increased vigilance by AOGCC, and identification of a major shallow gas zone has greatly reduced risk of future blowouts on the North Slope.

The AOGCC held hearings on drilling safety to determine whether changes to regulations were necessary in the aftermath of the Deepwater Horizon incident (the Deepwater Horizon rig was finishing work after drilling the Macondo exploration well in the Gulf of Mexico in 2010, when a kick escalated to a blowout, followed by a series of explosions and fire killing eleven men and releasing nearly 5 million barrels of oil (BOEMRE 2011)). The primary findings were that regulators should demand a safety culture; eliminate regulatory complexity; conduct inspections, enforce regulations, and monitor performance; keep the focus on regulating; and require a blowout contingency plan. AOGCC concluded that many of these recommendations were already in place in Alaska (PAME 2014).

b. Offshore Transportation

Alaska’s largest oil spill was the March 1989 Exxon Valdez tanker spill in Prince William Sound, the second largest spill recorded in US waters. It spilled nearly 10.8 million gallons of crude oil, contaminated fishing gear, fish and shellfish, killed numerous marine birds and mammals, and led to the closure or disruption of many Prince William Sound, Cook Inlet, Kodiak, and Chignik fisheries (Alaska Office of the Governor 1989; Graham 2003; University of North Carolina At Chapel Hill 2003; City of Valdez 2017). Effects of oils spills on fish and other wildlife are discussed in Chapter Eight.

Other large tanker spills include the 1987 tanker Glacier Bay spill of 2,350 to 3,800 barrels of North Slope crude oil being transported to Cook Inlet for processing at the Nikiski Refinery (ADEC 1988). Less than 10 percent of the oil was recovered, and the spill interrupted commercial fishing activities near Kalgin Island during the peak of the sockeye salmon run.

Both incidents demonstrated that preventing large tanker spills was easier than cleaning them up, and that focused legislative attention on the prevention and cleanup of oil spills on both the federal and state levels. At the state level, statutes created the oil and hazardous substance spill response fund (AS 46.08.010), established the Spill Preparedness and Response (SPAR) Division of ADEC (AS 46.08.100), and increased financial responsibility requirements for tankers or barges carrying crude oil up to a maximum of $100 million (AS 46.04.040(c)(1)).
c. Pipelines

Both state and federal agencies have oversight of pipelines in Alaska. State agencies include the ADEC and DO&G, which includes the State Pipeline Coordinator’s Section. Federal agencies include the PHMSA within the US Department of Transportation and the Bureau of Safety and Environmental Enforcement within the US Department of the Interior. Additionally, there is the Joint Pipeline Office which consists of a variety of state and federal agencies that oversee TAPS.

The pipeline system that transports North Slope crude includes flowlines that carry oil, gas, and produced water to processing facilities; transmission pipelines that carry oil to Pump Station 1, where it is delivered to TAPS; and TAPS which carries oil to the marine terminal at the Port of Valdez for transport to refineries. These pipelines vary in size, length, and content. As an example, a 14-inch pipeline can store about 1,000 barrels (bbl) per mile of pipeline length. Under static conditions, if oil were lost from a 5-mile stretch of this pipeline (a hypothetical distance between emergency block valves), a maximum of 5,000 bbl of oil could be discharged if the entire volume of oil in the segment drained from the pipeline.

In May 2007, the Alaska Risk Assessment (ARA) project was launched by the ADEC. The purpose of the three-year, $5 million initiative was to evaluate Alaska’s oil and gas infrastructure for its ability to operate safely. Based upon the results from Phase 1 of the investigation, the project scope was revised to focus on North Slope spills that result from loss of pipeline integrity. A North Slope Spills Analysis (NSSA) for specific North Slope pipelines was issued in November 2010 and updated in 2013, that compiled and analyzed the causes of pipeline spills (Nuka 2010, 2013). The spill analysis identified spills from flowlines accounted for the highest total amount of oil spilled, that the cause of most loss-of-integrity spills was most frequently valve or seal failure while corrosion was the most frequent cause of spills greater than 10,000 gallons, and that external corrosion was the dominant cause of flowline spills (Nuka 2010, 2013). Specific recommendations for reducing spills from North Slope infrastructure were developed from the ARA (Cycla Corporation 2010; ADEC 2017). Since this assessment, operators on the North Slope have increased monitoring, and completed numerous repairs and replacement of leaking valves and corroded pipeline sections.

Although there are risks associated with spills resulting from exploration, production, storage, and transportation of oil and gas, these risks can be mitigated through prevention and response plans such as the Regional and Area Contingency Plans (AKIAC 2018; ARRT 2018).

3. Spill and Leak Prevention

Several measures contribute to the prevention of oil spills during the exploration, development, production, and transportation of crude oil. Some of these prevention measures appear as mitigation measures in Chapter Nine, and some are discussed at the beginning of this section. Prevention measures are also described in the oil discharge and contingency plans that the industry must prepare before beginning operations. Thorough training, well-maintained equipment, and routine surveillance are required components of oil spill prevention.

If oil or gas is found in commercial quantities and production is proposed, the lessee will provide their transportation plans, which will be evaluated and adjudicated through the local state, and federal permitting processes. These processes will involve public participation and will consider any required changes in oil spill contingency planning and other environmental safeguards.

The oil industry employs, and is required to employ, many techniques and operating procedures to help reduce the possibility of spilling oil, including:

- Use of existing facilities and roads;
• Water body protection, including proper location of onshore oil storage and fuel transfer areas;
• Use of proper fuel transfer procedures;
• Use of secondary containment, such as impermeable liners and dikes;
• Proper management of oils, waste oils, and other hazardous materials to prevent ingestion by wildlife;
• Consolidation of facilities;
• Placement of facilities away from fish-bearing streams and critical habitats;
• Placement of pipelines to facilitate spilled oil containment and cleanup; and
• Installation of pipeline leak detection systems and shutoff devices.

These requirements are found in the mitigation measures for oil and gas leases and the lease stipulations for pipeline right-of-way leases.

a. Blowout Prevention

Oil, gas, and other hazardous substances may be released in a well blowout. BOPs greatly reduce the risk of a gas release. If a gas release occurs, the released gas will dissipate unless it is ignited by a spark. Each well has a blowout prevention program that is developed before the well is drilled. Operators review bottom-hole pressure data from existing wells in the area and seismic data to learn what pressures might be expected in the well. Engineers use this information to design a drilling mud program with sufficient hydrostatic head to overbalance the formation pressures from the surface to the total depth of the well. Engineers also design the casing strings to prevent various formation conditions from affecting well control performance. BOP equipment is installed on the wellhead after the surface casing is set and before actual drilling begins. BOP stacks are routinely tested in accordance with government requirements. Under 20 AAC 25.035, AOGCC regulates compliance with blowout prevention requirements.

If well control is lost and there is an uncontrolled flow of fluids at the surface, a well control plan is devised. The plan may include instituting additional surface control measures, igniting the blowout, or drilling a relief well. Regaining control at the surface is faster than drilling a relief well and has a high success rate. Operators may pump mud or cement down the well to kill it, replace failed equipment, remove part of the BOP stack and install a master valve, or divert the flow and install remotely operated well control equipment. All response actions would require approval by the established Unified Command for the incident.

b. Leak Detection

Leak detection systems and effective emergency shut-down equipment and procedures are essential in preventing discharges of oil and gas from any pipeline that might be constructed in the Sale Area. Once a leak is detected, valves at both ends of the pipeline, as well as intermediate block valves, can be manually or remotely closed to limit the amount of discharge. The number and spacing of the block valves along the pipeline will depend on construction codes, the size of the pipeline, and the expected throughput rate.

The technology for monitoring pipeline leaks is continually improving. Leak detection methods may be categorized as hardware-based (optical fibers or acoustic, chemical, or electric sensors), software-based (to detect discrepancies in flow rate, mass, and pressure), or a combination of both. Leak detection methods include acoustic monitoring, pressure point analysis, hydrocarbon vapor or
liquid sensing devices, regular ground and aerial inspections, and combinations of some or all of the different methods. The approximate location of a leak can be determined by the sensors along the pipeline. A computer network is used to monitor the sensors and signal any abnormal responses. When determining which leak detection system to use, an operator needs to consider the properties for each pipeline such as flow rate pattern, fluid and chemical properties, and temperature variation. Other factors that may affect the choice include pipeline field instrumentation, data interface, and telecommunication capability (Shannon and Wilson 2012).

In the early 2000s, computer-based leak detection through a Real-Time Transient Model was most commonly used to mathematically model the fluid flow within a pipe (Scott and Barrufet 2003). Pipeline systems built during this period, many of which are still in operation, are operated from control centers with computer connectivity and satellite and telecommunication links that strive for rapid response and constant monitoring of pipeline conditions (NRC 2003). Currently, the most common leak detection system in use by pipeline operators is the Supervisory Control and Data Acquisition (SCADA) system. This system uses computers to remotely monitor a variety of sensors along the pipeline and track pertinent data such as pressure, flow rates, temperature, and whether valves are open or closed. The sensors relay the information to a control room where operators monitor the system for anomalies and review any alarms that might arise. From the control room, pipeline operators can respond to a leak by remotely operating valves, pumps, and other equipment need to respond to a variety of situations.

ILI tools, commonly referred to as smart pigs are data collection devices that are run through the pipeline while it is in operation, that have greatly enhanced the ability of a pipeline operator to detect internal and external corrosion and differential pipe settlement in pipelines. Pigs can be sent through the pipeline on a regular schedule to detect changes over time and give advance warning of any potential problems and to quantify additional stresses that are not observed during surveillance. Caliper pigs are used to measure internal deformation such as dents or buckling. Geometry pigs record the configuration of the pipeline system and determine displacement. Wall thickness pigs measure the thickness of the pipeline wall. All can provide early warnings of weaknesses where leaks may occur (NRC 2003).

FLIR pipeline monitoring programs assists in detecting pipeline leaks and corrosion. Originally developed by the military, FLIR uses infrared sensors to sense heat differentials. A leak shows up as a “hot spot” in a FLIR video, in both daytime and nighttime images. Wet insulation surrounding a aboveground produced water, crude oil, or three-phase pipeline conducts more heat to the outer surface of the pipeline and contrasts with dry-insulated areas that is apparent under certain winter conditions FLIR usage for leak detection in aboveground pipelines is typically airborne surveys where it is effective in discovering wet insulation areas that have produced corrosion on the exterior wall of the pipeline (Shannon and Wilson 2012; Alyeska Pipeline Service Company 2020).

FLIR also has applications in spill response where infrared aerial photography can be used to determine the area of a spill quickly and accurately, distinguishing between oil and substances that might look like oil to human eyes. This allows swift and accurate reporting of the spill parameters to the appropriate agencies (NRC 2003). The incident command team can receive information near real-time and can therefore make timely decisions.

4. Oil Spill Response

Spill preparedness and response practices for the Sale Area are driven by the Alaska Regional Contingency Plan and the Alaska Inland Area Contingency Plan. The Regional and Area Contingency Plans represent a coordinated and cooperative effort by government agencies and were prepared jointly by the EPA, USCG, and ADEC (AKIAC 2018; ARRT 2018).
a. Incident-Command System

An Incident Command System (ICS) response is activated in the event of an actual or potential oil or hazardous material spill. The ICS system is designed to organize and manage responses to incidents involving several interested parties in a variety of activities. Since oil spills usually involve multiple jurisdictions, the joint federal and state response contingency plan incorporates a unified command structure in the oil and hazardous substance discharge ICS. The unified command consists of the FOSC, the State On-Scene Coordinator (SOSC), the Local On-Scene Coordinator (LOSC), and the responsible party On-Scene Coordinator. The ICS is organized around five major functions: command, planning, operations, logistics, and finance/administration (AKIAC 2018; ARRT 2018).

The Unified Command jointly makes decisions on objectives and response strategies; however, only one Incident Commander oversees the spill response. The Incident Commander is responsible for implementing these objectives and response strategies. If the responsible party is known, the responsible party Incident Commander may remain in charge until or unless the FOSC and SOSC decide that the responsible party is not doing an adequate job of response (AKIAC 2018; ARRT 2018).

b. Response Teams

The Alaska Regional Response Team (ARRT) monitors the actions of the responsible party. The ARRT is composed of representatives from 15 federal agencies and one representative agency from the State of Alaska. The ARRT is co-chaired by the USCG and EPA, while the ADEC represents the State. The team provides coordinated federal and state response policies to guide the FOSC in responding effectively to spill incidents. The Statewide Oil and Hazardous Substance Incident Management System Workgroup, which consists of the ADEC, industry groups, spill cooperatives, and federal agencies, published the Alaska Incident Management System (AIMS) for oil and hazardous substance response (ARRT 2018).

Each operator identifies a spill response team for their facility, and each facility must have an approved spill contingency plan. Company teams provide on-site, immediate response to a spill event. If it is safe to do so, responders first attempt to stop the flow of oil and may construct berms on land or deploy booms in water to contain the spill. Responders may deploy booms to protect major inlets, wash-over channels, and small inlets. Deflection booming may be placed to enclose smaller bays and channels to protect sensitive environmental areas. If the nature of the event exceeds the facility’s resources, the responsible party calls in its response organization. The spill response team:

- identifies the threatened area;
- assesses the natural resources, i.e., environmentally sensitive areas such as major fishing areas, spawning or breeding grounds;
- identifies other high-risk areas such as offshore exploration and development sites and tank-vessel operations in the area;
- obtains information on local tides, currents, prevailing winds, and ice conditions; and
- identifies the type, amount, and location of available equipment, supplies, and personnel.

It is especially important to prevent oil spills from spreading rapidly over a large area. Cleanup activities continue as long as necessary, without any time frame or deadline.
c. Training

Individual members of spill response teams must be trained in basic spill response; skimmer use; detection and tracking of oil; oil recovery on open water; river booming; radio communications; all-terrain vehicle, snowmachine, and four-wheeler operations; oil discharge, prevention, and contingency plan review; communication equipment operations; open water survival; oil spill burning operations; pipeline leak plugging; and spill volume estimations.

d. Response Organizations

Primary Response Action Contractors (PRAC) and Oil Spill Response Organizations (OSRO) may play an important role in a spill response. PRACs and OSROs are organizations that may enter into a contractual agreement with a responsible party, assisting the responsible party in spill cleanup operations. PRACs and OSROs can provide equipment, trained personnel, and additional resources. The Operations/Technical Manuals maintained by the PRACs and OSROs may be referenced in vessel or facility contingency plans and serve as supplementary reference documents during a response. OSROs generally have access to large inventories of spill equipment and personnel resources. The FOSC or SOSC may contract these assets for use (AKIAC 2018; ARRT 2018). If a regulated operator proposes to use the services of a response contractor to meet ADEC’s response planning requirements, the PRAC must be registered with ADEC.

Alaska Clean Seas (ACS) is a not-for-profit oil spill response cooperative whose purpose and mission are to provide personnel, material, equipment, and training to its members for responding to oil spills on the North Slope. Originally formed in 1979 under the name of ABSORB (Alaskan Beaufort Sea Oil Spill Response Body) to support offshore exploration ventures in the Alaskan Beaufort Sea, ACS was restructured in 1990 from an equipment cooperative into a full-response organization capable of handling both offshore and onshore emergencies with trained responders and response equipment. Membership is optional, and member companies pay an initiation fee, annual fee, daily rig fees when engaging in drilling, and annual production fees for facilities in production (ACS 2018). ACS is a registered PRAC with ADEC.

For an oil spill in the Sale Area, oil and gas operators who are members of ACS may call upon ACS for assistance with both spill planning and response. Members may also engage in mutual aid agreements with other ACS members, providing each other with shared resources, both personnel and equipment, in the event of a spill. ACS provides manpower and equipment resources from its main base in Deadhorse and from within each of the operating oilfield units to assist in spill containment and recovery. Members are entitled to refer to ACS resources in their contingency plans, and to represent to regulatory agencies and others, that these resources are available to them in the event of a spill. Responses to oil spills in the Sale Area by ACS is exclusively for ACS organization members. However, when authorized by the Board of Directors, ACS may also respond to non-member spills. In 2020, members of ACS include Alyeska Pipeline Service Company; ConocoPhillips Alaska, Inc.; Eni US Operating Company, Inc.; ExxonMobil Alaska Production Inc.; Great Bear Petroleum Operating LLC; Hilcorp Alaska, LLC; Oil Search (Alaska), LLC; Savant Alaska, LLC (ACS 2020).

Other OSROs are available in emergency situations include Alaska Chadux Corporation (Chadux), which can provide equipment and spill response personnel in the Sale Area. Chadux provides state and federal compliance services for some tank farms and barging operations. Although Chadux does not store equipment for large-scale spill response within the Sale Area, they are capable of mobilizing equipment to the Sale Area from response hubs around the state including Utqiagvik (Chadux 2019). Chadux is a registered PRAC with ADEC.
All regulated vessels operating in Alaska waters must have ADEC-approved contingency plans or Streamlined Plans as appropriate for the vessel size, cargo, and service. USCG allows vessels to meet federal response planning requirements for operation in federal waters through membership in an approved Alternative Planning Criteria. Non-tank vessels and barges operate under the Alternative Planning Criteria which is authored and held by the Alaska Maritime Prevention and Response Network (AMPRN). The AMPRN allows compliant vessels to operate without a Ship Escort/Response Vessel System in place. The AMPRN assists vessel owners and operators with compliance for US oil pollution prevention regulations by maintaining contact and coordination with the Marine Exchange of Alaska (MXAK). MXAK monitors and tracks marine vessel traffic around the state’s waters, alerting the USCG, vessel owners, operators, and spill responders when a vessel has lost power, incurred a casualty, or if it has entered an area to be avoided. Members of the AMPRN hold contracts with Chadux and Ukpeagvik Inupiat Corporation’s Arctic Response Services in the event of an emergency or casualty (AMPRN 2019; Chadux 2019; MXAK 2019).

e. Geographic Response Strategies

Geographic Response Strategies (GRS) are oil spill response plans that protect specific sensitive areas from the effects of oil following a spill (ADEC 2020b). The purpose of these map-based strategies is to save time during the critical first few hours after an oil spill. They provide the location of sensitive areas and where to deploy oil spill protection equipment.

A workgroup composed of local spill response experts and the state and federal agencies is in the process of developing the GRS with public input. Sites are selected based on environmental sensitivity, risk of being impacted from a water borne spill, and feasibility of successfully protecting the site with existing technology. Strategies focus on minimizing environmental damage, using as small a footprint as possible to support the response operations, and selecting sites for equipment deployment. On the Beaufort Sea coast, 59 sites have been identified as candidate sites for the development of the GRS (ADEC 2020b). GRS are not inclusive for all sensitive areas. In the event of a spill, consultation with resource management agencies is required. No GRS have been identified as candidate sites for the North Slope inland region. During spill response, the Incident Management Team works with the LOSC and the DNR’s Office of History and Archaeology to identify sensitive areas that may be present even if a GRS has not been developed.

5. Cleanup and Remediation

Cleanup includes the initial response, remediation, and restoration. The focus of the initial response is to gain control of the spill source; to contain the released oil; and to protect fish, wildlife, vegetation, and cultural resources; assess site conditions to track oil movement; and remove, store, and dispose of spilled oil. Remediation further reduces contamination through site and risk assessment; a remediation plan; and further removal, storage, and disposal of collected oil. Restoration attempts to re-establish the ecological conditions that existed prior to the spill which usually includes a monitoring program to assess the results of restoration (Jorgenson and Cater 1996).

To limit the most serious effects of a spill, the focus of responders is to remove the maximum amount of oil as soon as possible and to prevent the spill from reaching waters of the state. Spill containment and recovery tactics can include mechanical responses such as containment booms, dikes, berms and dams, pits, trenches and slots, on-water recovery, on-land recovery and sensitive area protection. Non-mechanical response can tactics include use of dispersants in water or in-situ burning of oily vegetation or pooled oil with advance approval from the Unified Command (Nuka 2014). The location of the spill (river, lake, pond, wetlands, mesic and dry tundra) and season (summer, freezeup, winter, breakup) are critical factors in determining cleanup techniques (Cater 2014).
2010; Nuka 2014; ACS 2017a, b). Responsible parties must follow the response tactics outlined in their contingency plans if they have one, and Unified Command must approve of response tactics if one is established.

The objective of spill cleanup and remediation on tundra is to promote ecological recovery and to prevent effects of cleanup from exceeding those caused by the spill. The objectives for tundra cleanup include minimizing: damage from the spilled material, damage from response actions, and the length of time for tundra recovery. Tussock tundra, the predominate vegetation type in the Sale Area, complicates treatment because tussocks may preclude the use of heavy equipment because they are easily crushed or scraped and scraping, trimming, and aeration may be impractical for removing or degrading contaminants (Cater 2010).

Specific concerns for spill cleanup in the Sale Area as identified for TAPS Sagavanirktok River Segment 2 and 3, Toolik/Kuparuk rivers, Itkillik River, Galbraith Lake, Atigun River contingency areas include protection of fish, raptors, waterfowl, and other birds; tundra marshes and ponds; preventing oil from reaching tributaries, rivers, lakes; and protecting moderate to highly erodible frozen soils. During high flow periods (rain or breakup) effective containment of oil may be limited to the area where oil enters the river and floating ice and aufeis may complicate in-river containment (ACS 2017a, b). Wildlife response would include removal of oiled carcasses, hazing/detering wildlife from oiled areas, capture handling transport, and release of unoiled wildlife away from the area or rehabilitation for oiled or injured wildlife, as well as avoidance of unnecessary disturbance to raptor nesting areas and Dall sheep lambing areas during sensitive periods (ARRT 2020).

After a spill, the physical and chemical properties of oil are altered, or weathered, by the physical, chemical, and biological characteristics of the environment. Important factors affecting spilled oil in the initial stages of cleanup are evaporation, water solubility, and movement. Typically, about 40 percent of most crude oils evaporate within a week. About 2 to 5 percent of crude oil may dissolve in water, with low solubility for high-molecular-weight constituents. Oil is transported on land by gravitational flow, groundwater movement, and diffusion with surface and subsurface movement in soils affected by soil porosity, permeability, texture, water saturation, and organic content. Over the long term, microscopic organisms (bacteria and fungi) degrade oil, with some constituents more degradable than others (Jorgenson and Cater 1996).

6. Hazardous Substances

Hazardous substances are identified as a large range of elements, compounds, and substances regulated by the EPA, ADEC, and other government agencies. In addition to petroleum products, waste products, toxic water pollutants, hazardous air pollutants, hazardous chemical substances, and other products presenting an imminent danger to public health or welfare are identified for prevention from release and response in cases of spills. AS 46.03.826(5). The three most prevalent extremely hazardous substances in the North Slope Geographic Zone are: 1) sulfuric acid, 2) hydrochloric acid, and 3) chlorine. The ADEC, USCG, and EPA would monitor and inspect operations and facilities in the Sale Area to enforce compliance with preventative measures to ensure safe use and storage of hazardous substances (AKIAC 2018). To minimize releases or spills during oil and gas operations, mitigation measures have been developed and can be found in Chapter Nine.

Spill response protocols are well established for the North Slope Geographic Zone. ADEC, USCG, and EPA – Region 10 have established guidelines for operations in the event of a major response effort to an oil spill or hazardous material release in the Arctic and Western Alaska and Alaska Inland Area Contingency Plans. Any release of a hazardous substance must be reported by a
responsible party, or any individual as soon as the person has knowledge of the discharge. The release must be reported to the National Response Center and the ADEC. There are several safeguards in place to react quickly to hazardous releases. Coordination, trained personnel, and technological advances can be employed quickly to address the occasions when releases occur (AKIAC 2018).

It is essential for those in command and control to identify the substance released for safe containment. An initial characterization of the hazard during the evaluation phase of containment requires an assessment of potential threat to public health and environment, need for protective actions, and protection of response personnel. A more comprehensive characterization will follow if necessary. In certain cases, local or state entities have the authority to order evacuations beginning with those living or working in downwind or in low-lying areas. Response personnel will secure sites, establish control points, and establish work zones. When an LOSC is available, the LOSC is in command and control until he or she determines an imminent threat to public safety no longer exists. While the largest volume of transport hazard substances are natural gas and crude oil, agency coordination between federal, state, and local entities are equipped to contain and manage releases of all hazardous substances present in the Sale Area (AKIAC 2018; ARRT 2018).

G. References


SPE (Society of Petroleum Engineers). 2018. Petroleum resources management system. Revised June 2018. Sponsored by: Society of Petroleum Engineers (SPE); World Petroleum Council (WPC); American Association of Petroleum Geologists (AAPG); Society of Petroleum Evaluation Engineers (SPEE); Society of Exploration Geophysicists (SEG); Society of Petrophysicists and Well Log Analysts (SPWLA); and European Association of Geoscientists & Engineers (EAGE).


Chapter Seven: Governmental Powers to Regulate Oil and Gas

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Chapter Seven: Governmental Powers to Regulate Oil and Gas

AS 38.05.035(g)(1)(B)(v) requires the director to consider and discuss the governmental powers to regulate the exploration, development, production, and transportation of oil and gas or gas only. Oil and gas activities are subject to numerous federal, state and local laws, regulations, policies, and ordinances. Each lessee is obligated to comply with all federal, state, and local laws. Regulatory agencies may have different roles in the oversight and regulation of oil and gas activities, and some agencies may have overlapping authorities with other agencies.

Most oil and gas activities require individual authorizations regardless of the phase (disposal, exploration, and development and production) with which they are associated. Common oil and gas activities associated with exploration requiring prior authorization include seismic surveys, development of drill pads, and drilling exploration wells. In the development and production phase, common activities requiring prior authorization include construction of pads, roads, support facilities, and drilling development wells. In the production phase, common oil and gas activities requiring prior authorization include constructing and operating processing facilities, constructing transmission pipelines, flowlines, and above-ground storage tanks. The likely methods of transportation in the production and development phase are focused on moving oil and gas, and regulatory authorities tend to shift toward monitoring activities and facilities in the field to ensure post-disposal oil and gas activities are conducted as approved. These phases are not always sequential and associated oil and gas activities may occur at any point throughout the project. The completion of one phase does not automatically trigger the beginning of a new phase.

This chapter is not intended to provide a comprehensive description of all laws and regulations that may be applicable to oil and gas activities. The intent is to display the broad spectrum of government agencies authorized to prohibit, regulate, and condition oil and gas activities that may ultimately occur because of the North Slope Foothills Areawide (Sale Area) lease sales. Actual processes, terms, conditions, and required authorizations will vary with time and certain, site-specific operations, and the activities discussed in the previous paragraph are not all inclusive. Lessees are responsible for knowing and complying with all applicable federal, state, and local laws, regulations, policies, ordinances, and the provisions of the lease. Some, but not necessarily all, of the major permits and approvals required by each agency are discussed below.

A. State of Alaska

The State of Alaska has several agencies that approve, oversee, or coordinate activities related to oil and gas exploration, development, production, and transportation. The lessee is required to keep the leased or unit area open for inspection by authorized state officials. Several state agencies including the Alaska Department of Natural Resources (DNR), Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADF&G), and Alaska Oil and Gas Conservation Commission (AOGCC) may monitor field operations for compliance with each agency’s terms. The agencies and their authorities are described below.

1. Alaska Department of Natural Resources

DNR reviews, coordinates, conditions, and approves plans of operations or development and other permits, as required, before on-site activities can take place. DNR monitors activities through field inspections once they have begun. Each plan of operations is site-specific and must be tailored to
the activity requiring the permit. Applicable fees for DNR permits and applications are outlined in 11 AAC 05.010.

a. Oil and Gas Lease

The Division of Oil and Gas (DO&G) has the authority under AS 38.05.035 and AS 38.05.180 to issue oil and gas leases. An oil and gas lease grants to the lessee, without warranty, the exclusive right to drill for, extract, remove, clean, process, and dispose of oil, gas, and associated substances in or under a specific tract of land. While an oil and gas lease grants the lessee exclusive rights to subsurface mineral interests, it does not authorize subsequent post-disposal oil and gas activities on the lease. The oil and gas lease serves as the agreement that disposes of state land.

b. Plan of Operations Approval

Oil and gas operations undertaken on or in the leased or unitized area are regulated by 11 AAC 83.158 and 11 AAC 83.346. An application for approval of a plan of operations must contain sufficient information for DO&G to determine the surface use requirements and impacts directly associated with the proposed operations. Amendments may be required as necessary, although DO&G will not require an amendment that is inconsistent with the terms of the sale under which the lease was obtained. The terms and conditions of the lease, including amendments to the plan of operations, are attached to the plan of operations approval, and are binding on the lessee. In addition to an approved plan of operations, a bond must be furnished to DNR in accordance with 11 AAC 83.160, before starting operations on a state oil and gas lease. The lessee is required to keep the leased or unit area open for inspection by authorized state officials.

c. Permits, Rights-of-Way, Easements

In addition to oil and gas activities on leased or unitized lands under plans of operations, DO&G has authority delegated by the commissioner to issue any required permits, rights-of-way, or easements on state land under AS 38.05.850, for roads, trails, ditches, field gathering lines or transmission and distribution pipelines not subject to AS 38.35, and for telephone or electric transmission and distribution lines, oil well drilling sites and production facilities for the purposes of recovering minerals from adjacent land under valid lease, and other similar uses or improvements.

d. Pipeline Rights-of-Way

Administrative Order 187 established the State Pipeline Coordinator’s Office in 1987 as the lead agency for the state in processing pipeline right-of-way leases under AS 38.35, the Right-of-Way Leasing Act. This responsibility includes coordination of the state’s efforts related to the federal right-of-way process. The State Pipeline Coordinator also coordinates the state's oversight of preconstruction, construction, operation, and termination of jurisdictional pipelines. In 2015, the State Pipeline Coordinator’s Office was incorporated into the organizational structure of DO&G as the State Pipeline Coordinator’s Section.

e. Temporary Water Use Authorization

Temporary water use authorizations may be required for oil and gas activities. The Division of Mining, Land, and Water (DMLW) administers temporary water use authorizations as required under 11 AAC 93.035 before (1) the temporary use of a significant amount of water, (2) if the use continues for less than 5 consecutive years, and (3) the water applied for is not otherwise appropriated. The volume of water to be used and permitted depends upon whether it is for consumptive uses, and the duration of use. The authorization may be extended one time for good cause for a period not to exceed 5 years. The authorization is subject to conditions and may be suspended or terminated if necessary to protect the water rights of other persons or the public.
interest. Information on lake bathymetry, fish presence, and fish species may be required when winter water withdrawal is proposed to calculate the appropriate withdrawal limits.

**f. Permit and Certificate to Appropriate Water**

Industrial or commercial water use requires a Permit to Appropriate Water under 11 AAC 93.120. The permit is issued for a period consistent with the public interest and adequate to finish construction and establish full use of water. The maximum duration for this permit is 5 years, unless the applicant proves, or the commissioner independently determines, a longer time is required. The commissioner may issue a permit subject to terms, conditions, restrictions, and limitations necessary to protect the rights of others, and the public interest. Under 11 AAC 93.120(c), permits are subject to conditions to protect fish and wildlife habitat, recreation, navigation, sanitation or water quality, prior appropriators, or any other purpose DNR determines is in the public interest.

**g. Land Use Permits**

DO&G issues miscellaneous land use permits for geophysical exploration under 11 AAC 96.010. Geophysical exploration permits are required for all geophysical exploration activity in the Sale Area. Seismic surveys are the most common activity authorized by this permit. The purpose of this permit is to minimize adverse effects on the land and its resources while making important geological information available to the state (11 AAC 96.210). Under AS 38.05.035(a)(8)(C), the geological and geophysical data made available to the state are held confidential at the request of the permittee. A $100,000 bond is required to conduct seismic surveys. Under 11 AAC 96.060, DO&G reserves the right to determine the type and amount of security based on the scope and nature of the activity planned and the potential cost of restoring the permit site. The bond amount for other types of geophysical surveys is determined when the activity is proposed. A geophysical exploration permit contains measures to protect the land and resources of the area.

DMLW issues land use permits to manage surface uses and activities on state public domain land and to minimize adverse effects on the land and its resources under 11 AAC 96. Land use permits may be required for some oil and gas activities, unless the activities are otherwise approved under any DNR-administered lease, oil and gas exploration license, plan of operations, contract, or permit (11 AAC 96.007). Land use permits may be issued for a period of up to 5 years depending on the activity and may be revoked at will or for cause in accordance with 11 AAC 96.040. Generally allowed uses on state land are subject to the conditions set out in 11 AAC 96.025.

**h. Material Sale Contract**

If the lessee or operator proposes to use state-owned gravel or other materials for construction of pads and roads, DMLW requires a material sale contract (11 AAC 71). The contract must include, at a minimum, a description of the site, materials to be extracted, volume of material to be extracted, method of removal, bonds and deposits required of the purchaser, and the purchaser's liability under the contract. The material sale contract must also include the purchaser's site-specific operating requirements (11 AAC 71.200). A contract may be extended if the DMLW director determines the delay in completing the contract is due to unforeseen events beyond the purchaser’s control, or the extension is in the state’s best interests (11 AAC 71.20). The purchaser may be required to provide a performance bond guaranteeing performance of the terms of the contract. If required, the bond amount is based on the total value of the sale and must remain in effect for the duration of the contract unless released in writing by the DMLW director (11 AAC 71.095).
Chapter Seven: Governmental Powers to Regulate Oil and Gas

i. Office of History and Archaeology

The Office of History and Archaeology (OHA) performs the work of the State Historic Preservation Office pursuant to the National Historic Preservation Act of 1966 (OHA 2020b). OHA follows the state’s historic preservation plan in maintaining the Alaska Heritage Resources Survey (AHRS). The historic preservation plan guides preservation activities in the state from 2018 through 2023 (OHA 2018). AHRS is an inventory of all reported historic and prehistoric sites within the state. This inventory includes objects, structures, buildings, sites, districts, and travel ways, with a general guideline that the sites are over 50 years old. The fundamental use of the AHRS is to protect cultural resource sites from unwanted destruction (OHA 2020a). Before beginning a multi-phase development project, information regarding important cultural and historic sites should be obtained by contacting OHA. The AHRS data sets are “restricted access documents” and site-specific location data should not appear in final reports or be distributed to others.

AS 41.35.010 enables the state to preserve and protect the historic, prehistoric, archaeological, and paleontological resources of Alaska from loss, desecration, and destruction so the scientific, historic, and cultural heritage embodied in these resources may pass undiminished to future generations. Further, the historic, prehistoric, archaeological, and paleontological resources of the state are the subject of concerted and coordinated efforts exercised on behalf of the public, so these resources may be located, preserved, studied, exhibited, and evaluated.

2. Alaska Department of Environmental Conservation

ADEC has the statutory responsibility to conserve, improve, and protect Alaska’s natural resources and environment, by regulating air quality, environmental health, water quality, and oil and hazardous substance spill prevention and response. ADEC implements and coordinates several federal regulatory programs in addition to state laws (ADEC 2020c).

a. Air Quality Permits

ADEC administers the federal Clean Air Act (42 USC §§ 7401-7671 et seq.) and the state’s air quality program under the federally approved State Implementation Plan (AS 46.14; 18 AAC 50). Through this plan, federal requirements of the Clean Air Act are met, including National Ambient Air Quality Standards (NAAQS), Non-Attainment New Source Review (N-NSR), New Source Performance Standards (NSPS), National Emission Standards for Hazardous Air Pollutants (NESHAP), and Prevention of Significant Deterioration (PSD). Additionally, ADEC monitors air quality and compliance.

NAAQS set limits on certain pollutants (called criteria pollutants) considered harmful to public health and the environment. NAAQS have been established for: carbon monoxide, lead, nitrogen dioxide, particulate matter (PM10), small particulate matter (PM2.5), ozone, ammonia, and sulfur dioxide. NSR and PSD, a permitting program required for the review of new sources, new construction projects, or modifications to an existing facility, ensures that air quality is not degraded by new projects, and that large, new, or modified industrial sources are as clean as possible (EPA 2020b). NSPS are intended to promote the use of the best air pollution control technologies available, and account for the cost of technology and any other non-air quality, health and environmental impact, and energy requirements (EPA 2017). NESHAPs are set for air pollutants (air toxics) that are not covered by NAAQS, but that may be harmful (EPA 2020a). The standards are categorized by type of source and require the maximum degree of reduction in emissions that is achievable, as determined by the US Environmental Protection Agency (EPA).

Title I Construction Permits and Title V Operations Permits are the two primary types of permits issued to meet air quality requirements. These permits specify what activities are allowed, what
emission limits must be met, and may specify how the facility must be operated. The permits contain monitoring, recordkeeping, and reporting requirements to ensure that the applicant meets the permit requirements (ADEC 2020d).

i. Title I Construction Permits

Title I permits refer specifically to air construction permits and minor source specific permits for certain activities such as the PSD program as well as other requirements of the Clean Air Act. This permit must be obtained before onsite construction may begin. Operators of existing and new facilities who propose to construct or modify a stationary source may need to apply for either a construction or minor source specific permit. Title I permits are required for projects that are new major sources for pollutants, or major modifications at existing sources. PSD requires installation of the “Best Available Control Technology,” an air quality analysis, and additional impacts analysis and public involvement (EPA 2019).

The process for a Title I permit can take up to 3 years, depending on the amount of pre-construction meteorological or pollutant monitoring data that must be collected. Once a complete Title I permit application is submitted, ADEC strives to issue Title I minor permits within 130 days. Title I PSD permits can take up to 18 months to issue once a complete permit application is received. Article 5 of 18 AAC 50 contains the regulations covering Title I minor permits. Article 3 of 18 AAC 50 contains the regulations covering the Title I PSD permits. With a few exceptions, ADEC has adopted the federal PSD permit program under 40 CFR 52.21 by reference.

ii. Title V Operations Permits

The federal Clean Air Act gives EPA authority to limit emissions from air pollution sources after the source has begun to operate. EPA regulations require facilities that emit certain pollutants or hazardous substances to obtain a permit to operate the facility, known as a Title V permit. In Alaska, ADEC is responsible for issuing Title V permits and making compliance inspections (AS 46.14; 18 AAC 50). The permit establishes limits on the type and amount of emissions, requirements for pollution control devices and prevention activities, and requirements for monitoring and record keeping (ADEC 2020d).

If a Title V permit is required, a permittee has up to 1 year after becoming a major source to submit a complete Title V permit application. Operations can continue while ADEC processes the application (the application shield) if the application is both timely and complete. However, significant revisions to an existing permitted facility cannot be made until ADEC approves the permit revision. Processing time for permit revisions can generally take up to 6 months. Title V permits and revisions can be processed concurrently with Title I permits. Article 3 of 18 AAC 15 contains the regulations covering Title V permits. With a few exceptions, ADEC has adopted the federal operating permit program under 40 CFR Part 71 by reference.

iii. Other Requirements

ADEC operates ambient air quality monitoring networks to assess compliance with NAAQS for carbon monoxide, particulates, nitrogen dioxide, sulfur oxide, and lead; assesses ambient air quality for ambient air toxics levels; provides technical assistance in developing air monitoring plans; and issues air advisories to inform the public of hazardous air conditions (ADEC 2020a). ADEC provides oversight for operators that must collect air quality and meteorological data to meet air permit requirements.

b. Solid Waste Permits

ADEC regulates solid waste storage, treatment, and disposal under 18 AAC 60. Solid waste disposal permit applications are reviewed for compliance with air and water quality standards,
wastewater disposal, drinking water standards, and consistency with the Alaska Historic Preservation Act before approval. A comprehensive facility plan is required and includes specific engineering design criteria and a discussion demonstrating how the various design features (liners, berms, dikes) will ensure compliance with regulations. Disposal of waste in Municipal Solid Waste Landfills is regulated under 18 AAC 60.300-398. Non-municipal landfills, also known as monofills, are classified and regulated according to the types of waste under 18 AAC 60.400-495. Non-hazardous drilling waste storage and landfills, or reserve pits, fall under this regulation. Reserve pits were used for drilling waste disposal prior to 1996 and are required to be closed under 18 AAC 60.440. Currently 95 percent of the identified inactive reserve pits have met closure requirements.

Waste storage, treatment, and land applications facilities also require permits under 18 AAC 60. Permit applications include detailed reviews of design and operations to ensure that the facilities will perform their planned function, comply with other ADEC regulations, and be protective of health, safety and the environment. Typical permitted waste treatment facilities include municipal solid waste incinerators and treatment facilities for medical waste, sewage solids, and drilling waste (prior to underground injection). In addition, temporary storage of drilling waste is regulated under 18 AAC 60.430 for short term storage or a general permit for long term storage facilities on the North Slope. Other large storage facilities are evaluated based on the specific waste and site characteristics.

c. Wastewater Discharge Permits

ADEC’s Oil and Gas Section issues state permits for wastewater discharges to land and Alaska Pollutant Discharge Elimination System (APDES) permits for wastewater discharges to Waters of the United States for the oil and gas industry. Permits are issued to the oil and gas operators based on local knowledge and conditions, receiving water characteristics, industry processes, and treatment technology used by the industry. Facilities related to oil and gas exploration, development, or production activities that seek to discharge wastewater to surface waters must apply for an APDES permit. Two types of APDES permits are available general permits and individual permits; and two general permits apply to oil and gas activities in the Sale Area (North Slope general permit AKG332000 and Pipeline general permit AKG320000). When a general permit is not available for a specific oil and gas industry discharge from an activity or facility, or when aspects of a facility are not addressed in a general permit, an applicant may request, ADEC may require, or the public may petition the development of an individual permit (ADEC 2020b).

The North Slope general permit applies to wastewater discharges from oil and gas facilities within the North Slope Borough AKG332000. This permit covers discharges from graywater, gravel pit dewatering, excavation dewatering, hydrostatic test water, construction stormwater, industrial stormwater, mobile spill response, and secondary containment. The Pipeline general permit covers certain wastewater discharges from construction, operation, and maintenance activities for significant oil and gas pipelines. In addition to the discharges authorized under the North Slope general permit, the Pipeline general permit also applies to wastewater discharges from drilling fluids and cuttings, and domestic wastewater (ADEC 2020b).

d. Industry Oil Discharge Prevention and Contingency Plans

ADEC regulates spill prevention and response under AS 46.04.030. ADF&G and DNR support ADEC in these efforts by providing expertise and information. Oil discharge prevention and contingency plans (contingency plans) must be filed with ADEC before beginning operations. DNR reviews and provides comments to ADEC regarding the adequacy of these contingency plans. Contingency plans for exploration facilities must include a description of methods for responding to and controlling blowouts, the location and identification of oil spill cleanup equipment, the location
and availability of suitable drilling equipment, and an operation plan to mobilize and drill a relief well. Holders of approved plans are required to have enough oil discharge containment, storage, transfer, cleanup equipment, personnel, and resources to meet the response planning standards for the type of facility, pipeline, tank vessel, or oil barge (AS 46.04.030(k)). If development and production follow, additional contingency plans must be approved for each facility before activity begins.

Contingency plans must describe existing and proposed means of oil discharge detection, including surveillance schedules, leak detection, observation wells, monitoring systems, and spill-detection instrumentation (AS 46.04.030; 18 AAC 75.425(e)(2)(E)). Contingency plans must include: a Response Action Plan, a Prevention Plan, and Supplemental Information to support the response plan, including a Best Available Technology Section (18 AAC 75.425). Operators must also provide proof of financial ability to respond to damages (AS 46.04.040).

All discharges of oil or hazardous substances must be reported to ADEC. The report must include the volume released, whether the release was to land or to water, and whether the release was contained by a structure or secondary containment. Discharge must be cleaned up to ADEC’s satisfaction. ADEC may modify proposed cleanup techniques and/or require additional cleanup techniques for the spill site as necessary to protect human health, safety, welfare, and the environment (18 AAC 75.335(d)).

e. Interference with Salmon Spawning Streams and Waters Permits

ADEC is responsible for issuing permits for activities that interfere with salmon spawning streams and waters. Activities that may potentially obstruct, divert, or pollute waters of the state used by salmon for spawning, or that may interfere with the free passage of salmon must first apply for and obtain a permit before beginning any work (AS 16.10.010). Permits may be granted if ADEC finds the purpose of the permit is to develop power, obtain water for civic, domestic, irrigation, manufacturing, mining, or other purposes with the intent to develop the state’s natural resources. The applicant may also be required to construct and maintain adequate fish ladders, fishways, or other means by which fish may pass over, around, or through the dam, obstruction, or diversion in the pursuit of spawning.

3. Alaska Department of Fish and Game

ADF&G, Division of Habitat, evaluates the potential effect of any activity on fish and wildlife, their habitat, and the users of those resources. ADF&G manages approximately 750 active fisheries, 26 game management units, and 32 special areas. The Division of Habitat’s mission is to protect Alaska’s valuable fish and wildlife resources and their habitats as Alaska’s population and economy continue to expand. For activities in the Sale Area, fish habitat and wildlife hazing permits (5 AAC 92.033) may be required.

a. Fish Habitat Permits

Under AS 16.05.841–.871, ADF&G has the responsibility to protect freshwater anadromous fish habitat and provide free passage for anadromous and resident fish in freshwater bodies. ADF&G also regulates any activity or project that is conducted below the ordinary high-water mark of an anadromous stream. These activities include, but are not limited to, construction and maintenance for bridges and culverts, ice roads and bridges, stream diversion, stream crossing, and using explosives in the bed of a specified river, lake, or stream. ADF&G may attach additional stipulations to any permit authorization to mitigate potentially negative effects of the proposed activity.
b. Special Area Permits

Under AS 16.20, authorization for land and water use activities that may impact fish, wildlife, habitats, or existing public use in any of the refuges, sanctuaries, or critical habitat areas designated by the Alaska legislature, may require a special area permit. There are currently no special areas in the Sale Area that would require a special area permit from ADF&G.

4. Alaska Oil and Gas Conservation Commission

AOGCC is an independent, quasi-judicial agency of the State of Alaska established under the Alaska Oil and Gas Conservation Act, AS 31.05.005, AOGCC’s regulatory authority is outlined in 20 AAC 25. AOGCC acts to prevent waste, protect correlative rights, improve ultimate recovery, and protect underground freshwater. It issues permits and orders and administers the Underground Injection Control (UIC) program for Class II injection wells for enhanced oil recovery and underground disposal of oil field waste. AOGCC serves as an adjudicatory forum for resolving certain oil and gas disputes between owners, including the state (AOGCC 2020a).

a. Permit to Drill

Under AS 31.05.090, AOGCC is authorized to issue permits to drill. Any lessee wishing to drill a well for oil, gas, or geothermal resources must first obtain a permit to drill from AOGCC. This requirement applies to exploratory, stratigraphic test and development wells, and injection and other service wells related to oil, gas, and geothermal activities. Typically, operating companies have obtained approval from all other concerned agencies by the time an operator, as defined by 20 AAC 25.990(46), applies to AOGCC for a permit to drill. The application must be accompanied by the items set out in 20 AAC 25.005(c).

Under 20 AAC 25.015, once a permit to drill has been approved, the operations detailed in the permit to drill application must not be changed without additional approval from AOGCC. After issuance of a permit to drill, information on the surface and proposed bottom-hole locations and the identity of the lease, pool, and field for each well is published as part of AOGCC’s weekly drilling report (AOGCC 2020b).

b. Plan of Reservoir Development and Operation

Before a new reservoir pool may be developed a Plan of Reservoir Development and Operation with detailed reservoir information must be submitted. The plan is reviewed by AOGCC to assess whether the proposed operations will prevent waste, protect correlative rights, and ensure maximum recovery of oil and gas from the pool as specified in 20 AAC 25.517. AOGCC undertakes independent analysis of subsurface data to assess recovery efficiencies for oil and gas reservoirs (AOGCC 2020c)

c. Conservation Orders

In response to an application or under its own motion, the AOGCC will hold hearings and issue conservation orders to allow activities that are in variance to AOGCC regulations if needed to prevent waste, maximize recovery and protect correlative rights (see 20 AAC 25.252).

d. Underground Injection Control Program

The goal of the UIC program under the federal Safe Drinking Water Act is to protect underground sources of drinking water from contamination by oil and gas (Class II) injection activities. The UIC program requires the AOGCC to verify the mechanical integrity of injection wells, determine if appropriate injection zones and overlying confining strata are present, determine the presence or absence of freshwater aquifers and ensure their protection, and prepare quarterly reports of both in-
house and field monitoring for EPA. Through a Memorandum of Understanding with EPA, AOGCC has primacy for Class II wells in Alaska, including enhanced oil recovery wells, hydrocarbon storage wells, and oilfield waste disposal wells (AOGCC 2020c).

AOGCC reviews and takes appropriate action on proposals for the underground disposal of Class II oil field wastes (20 AAC 25.252). Before receiving approval, an operator must demonstrate that injected fluids will not move into freshwater sources. Disposal or storage wells must be cased and the casing cemented in a manner that will isolate the disposal or storage zone and protect oil, gas, and freshwater sources. Once approved, liquid waste from drilling operations may be injected through a dedicated tubing string into the approved subsurface zone.

e. Annular Disposal of Drilling Waste

An AOGCC permit is required if drilling wastes are to be injected into the well annulus. Annular disposal provides an efficient means for on-site and safe disposal of waste from drilling activities. AOGCC reviews and approves specific wastes, generally limited to drilling muds and cuttings, for annular disposal and ensures that wells permitted for annular disposal will safely contain injected drilling waste (AOGCC 2020c).

f. Area Injection Orders

Area injection orders describe, evaluate, and approve subsurface injection on an area wide basis for enhanced oil recovery and disposal purposes (20 AAC 25.402; AOGCC 2020c).

g. Surveillance

AOGCC’s surveillance activities ensure that operators prevent waste and maximize recovery of oil and gas. AOGCC inspectors oversee blowout prevention equipment tests after installation of the surface casing on all exploratory wells and wells that might encounter abnormally pressured zones, as well as on each rig at start up, after major moves, and every two months on a routine basis. Diverter tests are also witnessed on all wells requiring a diverter because of known or probable shallow gas sands.

AOGCC inspectors witness initial mechanical integrity tests on all new injection wells, workovers, and repairs to injection wells, about 60 percent of subsequent integrity tests on Class II wells, and plugging and abandonment of all Class II injection wells. Setting of critical cement plugs in wells during abandonment are witnessed, unless the well is being abandoned to re-drill a new location within the same pool.

AOGCC engineers and inspectors also verify the accuracy of crude oil sales meters used for royalty and severance tax determinations. To eliminate unnecessary flaring whenever possible in accordance with 20 AAC 25.235, AOGCC has oversight of gas flaring activities. AOGCC analyzes and investigates as necessary flaring events over 1 hour and the operator may be penalized if it is determined that waste has occurred (AOGCC 2020c). Between 2013 and 2017 an average of 0.2 percent of produced natural gas was vented and flared (USDOE 2019).

5. Alaska Department of Labor and Workforce Development

The Alaska Department of Labor and Workforce Development (DOLWD) administers the state’s unemployment insurance program through the Alaska Employment Security Act under AS 23.20 and 8 AAC 85. DOLWD also administers some delegated authorities of the Occupational Safety and Health Administration (OSHA). Section 18 of OSHA Act of 1970 allows states to obtain approval to assume responsibility for development and enforcement of federal occupational safety and health standards. The DOLWD has obtained approval from OSHA for administration of some of the federal OSHA standards (DOLWD 1992; OSHA 2004).
B. Federal

1. US Environmental Protection Agency

EPA implements, administers, or oversees programs required by federal environmental laws and regulations. The implementation of some programs has been delegated to the states to safeguard the air, land, and water. EPA administers the Resource Conservation and Recovery Act (RCRA) relating to hazardous wastes and Underground Injection Control (UIC) Class I injection wells. AOGCC regulates UIC Class II oil and gas waste management wells.

a. Air Quality Permits

ADEC administers the federal Clean Air Act and the air quality program for the State of Alaska under a federally-approved state implementation plan (EPA 2018). For more information, see section A.2(a) above.

b. Hazardous Waste Permits

Hazardous waste storage, treatment, and disposal facilities are permitted and regulated by EPA. The federal RCRA regulates the management of solid waste, hazardous waste, and underground storage tanks holding petroleum products or certain chemicals (40 CFR 264.175(b)-(c)). Regulations set the parameters for transporting, storing, and disposing of hazardous wastes and for designing and operating treatment, storage, and disposal facilities safely (40 CFR 264.193(b)). Regulations are enforced through inspections, monitoring of waste handlers, taking legal action for noncompliance, and providing compliance incentives and assistance (EPA 2020c).

Some states may receive authorization to administer parts of the program, which requires that state standards be at least as strict as federal standards. EPA administers the RCRA program in Alaska. Currently, no hazardous waste disposal facilities are permitted in Alaska. If a hazardous waste management facility is proposed for Alaska, ADEC would be responsible for reviewing facility siting under 18 AAC 63.

c. National Pollutant Discharge Elimination System Discharge Permits

A National Pollutant Discharge Elimination System (NPDES) discharge permit is required under the federal Clean Water Act, although its administration may be delegated to a state agency. ADEC administers this EPA program within state waters, under the APDES (see section A.2(c) above). However, EPA retains responsibility for issuing NPDES permits in Alaska for facilities within Denali National Park, outside of state waters, on tribal lands, and facilities subject to Clean Water Act Section 301(h) waivers. Both ADPES and NPDES permits specify the type and amount of pollutant that may be discharged, and include monitoring and reporting requirements, such that discharges do not harm water quality or human health.

d. Underground Injection Control Class I and II Injection Well Permits

EPA regulates injection wells used to dispose of fluid pumped into wells. Authorized as part of the federal Safe Drinking Water Act of 1974, the EPA’s UIC program protects underground sources of drinking water from being contaminated by the waste injected into wells. Injection wells are categorized into five classes; Classes I and II are most common in the oil and gas industry. The EPA administers the program for Class I wells in Alaska, and authority for Class II oil and gas wells has been delegated to AOGCC (see section A.4(d) above). Class II injection wells are used to inject fluids or gasses associated with oil and natural gas production and may include disposal wells, enhanced oil recovery wells, or hydrocarbon storage wells.
Class I wells inject hazardous and non-hazardous industrial or municipal wastes into deep, confined rock formations. All injections falling into Class I must operate under an EPA permit that is valid for up to 10 years. Permits set requirements such as siting, construction, operation, monitoring and testing, reporting and record keeping, and closure. Requirements differ for wells depending on whether they accept hazardous or non-hazardous wastes.

2. US Army Corps of Engineers

The US Army Corps of Engineers (USACE) has regulatory authority over construction, excavation, or deposition of materials in, over, or under navigable waters of the United States, or any work which would affect the course, location, condition, or capacity of those waters under Section 10 of the Rivers and Harbors Acts of 1890 (superseded) and 1899 (33 USC 401, et seq.; 33 USC 403). In addition, under Section 404 of the Clean Water Act, USACE regulates discharge of dredged and fill material into waters of the United States including wetlands (USACE 2020b).

The primary goals of the USACE’s regulatory program are to maintain navigation (Section 10), and to restore and maintain the physical, chemical, and biological integrity of the nation’s waters (Section 404; USACE 2018). Section 10 permits cover oil and gas activities with potential to impact navigability of the Colville River to its confluence with the Etivluk River and the Sagavanirktok River to its confluence with the Atigun River within the Sale Area (USACE 2020a). Oil and gas activities that would likely require Section 10 permits could include bridge or pipeline crossings of these rivers, or construction of facilities that could affect the course of the Colville or Sagavanirktok rivers. Section 404 permits cover oil and gas activities that potentially discharge fill materials into waters of the United States, which are defined as “those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce (USACE 2020b).” Oil and gas activities that may require Section 404 permits could include placement of gravel fill for roads, drill site and facility pads, and bridge or pipeline pilings in wetlands, floodplains, streams and rivers.

Individual permits issued for specific projects are the basic type of permits issued. General Section 10 and 404 permits (including nationwide, and regional general permits) authorize activities that are minor and will result in minimal individual and cumulative adverse effects. General permits carry a standard set of stipulations and mitigation measures. Letters of permission, another type of permit authorization, are applicable to certain activities regulated under Section 10 in Alaska that do not involve discharge of fill in navigable waters (USACE 2018).

In making a final decision on whether to issue a Section 10 or 404 permit, USACE is required to consider the public interest. USACE considers the benefits and detriments of the proposed project on public resources including: conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and any other factors considered important for the needs and welfare of the people (USACE 2020b). Section 10 and 404 permits must also comply with other federal and state requirements. Permits are typically reviewed by EPA, US Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS) to ensure compliance with Endangered Species Act (ESA), National Environmental Policy Act, Fish and Wildlife Coordination Act, Essential Fish Habitat Provisions of the Magnuson-Stevens Fishery Conservation and Management Act, and National Historic Preservation Act (USACE 2018).

ADEC reviews Section 10 and 404 permit applications for compliance with Alaska water quality standards (Section 401 state certification). If the applications comply, ADEC issues a Certificate of Reasonable Assurance which allows the 404 permit to become valid (USACE 2020b).
3. Pipeline and Hazardous Materials Safety Administration

The Office of Pipeline Safety (OPS) in the Pipeline and Hazardous Materials Safety Administration (PHMSA), an agency of the US Department of Transportation, regulates movement of hazardous materials by pipeline (PHMSA 2018). PHMSA inspectors review technical issues on hazardous liquid pipelines in Alaska. The Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act Of 2016 requires gas and hazardous liquid pipeline operators to develop integrity management programs for transmission pipelines (PHMSA 2020).

Jurisdictional authority over pipelines depends on many factors such as design, pipe diameter, product transported, or whether it meets state or federal designation, e.g., transmission line, gathering line, or distribution line, and other attributes as specified in regulations. Generally, the design, maintenance, and preservation of transmission pipelines transporting hydrocarbon products are under the authority and jurisdiction of PHMSA with specific federal regulations for natural gas (49 CFR 192) and hazardous liquids (49 CFR 195). Both regulations prescribe the minimum requirements that all operators must follow to ensure the safety of their pipelines and piping systems. The regulations not only set requirements, but also provide guidance on preventive and mitigation measures, establish time frames for upgrades and repairs, development of integrity management programs, and incorporate other relevant information such as standards, incorporated by reference, developed by various industry consensus organizations.

4. National Marine Fisheries Service

NMFS is an office of the National Oceanic and Atmospheric Administration within the US Department of Commerce. NMFS is tasked with conservation and enhancement of Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act (NOAA Fisheries 2020). EFH in the Sale Area may include the Colville, Killik, Chandler, Itkillik, Ivishak, and Sagavanirktok rivers used by chum and pink salmon managed under the Salmon Fishery Management Plan (NPFMC et al. 2012; NMFS 2017).

5. US Fish and Wildlife Service

The mission of USFWS, an agency within the Department of the Interior, is working with others to conserve, protect, and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. USFWS’s authorities relevant for the Sale Area include migratory birds including bald and golden eagles, the national wildlife refuge system – Arctic National Wildlife Refuge, aquatic resources – National Wetlands Inventory, law enforcement, wildlife and sport fish restoration, environmental contaminant research, spill response and restoration, and subsistence management (USFWS 2019, 2020).

6. US Coast Guard

The US Coast Guard (USCG) has authority to regulate oil pollution under 33 CFR §§ 153–157 in waters of the United States, and to make determinations on hazards to navigation under 33 CFR § 64.31. USCG may respond to discharges or threats of discharges of oil and hazardous substances into the navigable waters of the United States and promulgate certain pollution prevention regulations under 33 USC § 1321. USCG evaluates hazards to navigation including bridge and pipeline crossings and regulates hazardous materials in commerce under USC Title 49. USCG safeguards fisheries and protected resources by enforcing living natural resource authorities like the Magnuson-Stevens Fisheries Conservation and Management Act (16 USC § 1801), the Lacey Act (16 USC §§ 3371–3378), and the Endangered Species Act (16 USC §§ 1531–1544).
C. Other Federal and State Regulatory Considerations

1. Regulation of Oil Spill Prevention and Response

Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 USC § 9605), and § 311(c)(2) of the Clean Water Act, as amended (33 USC § 1321(c)(2)) require environmental protection from oil spills. CERCLA and the Clean Water Act require a National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR § 300; 33 USC § 1321(d)). Under the implementing regulations, a violator must plan to prevent and immediately respond to oil and hazardous substance spills and be financially liable for any spill cleanup. If the pre-designated Federal On-Scene Coordinator (FOSC) determines the response is neither timely nor adequate, the federal government may elect to respond to the spill absent adequate actions by the responsible party and if it so chooses, may seek to recover the costs of such response from the responsible party.

The Oil Pollution Act of 1990 (OPA 90) requires the development of facility and tank vessel response plans and an area-level planning and coordination structure to coordinate federal, regional, and local government planning efforts with the industry. OPA 90 amended the Clean Water Act (§ 311(j)(4); 33 USC § 1231(j)) and established regional citizen advisory councils (RCACs) and area contingency plans as the main parts of the national response planning structure.

The Alaska Regional Response Team (ARRT) is an advisory board to the FOSC. It provides processes for participation by federal, state and local governmental agencies to participate in response to pollution incidents (ARRT 2014). The Alaska Regional Contingency Plan is the area contingency plan for Alaska (ARRT 2014). Since Alaska is large and geographically diverse, federal agencies also prepare geographic-specific contingency plans. The Sale Area is covered by the Arctic and Western Alaska area contingency plan (AWAAC 2018).

2. Alaska National Interest Lands Conservation Act

The Alaska National Interest Lands Conservation Act (ANILCA) designated over 100 million acres of conservation system units (CSUs) across Alaska, which are each separately managed by one of four federal land management agencies, the National Park Service, the USFWS, the Bureau of Land Management (BLM) and the USDA Forest Service. ANILCA includes numerous special provisions intended by Congress to balance the national interest in Alaska’s vast scenic and wildlife resources with recognition of Alaska’s developing economy and infrastructure, and distinctive rural way of life. The state, through its interagency ANILCA program, continues to closely monitor the implementation of ANILCA. State interests include the need for continued public access for traditional activities; guaranteed access to state and private inholdings within CSUs for economic and other uses; consideration of transportation and utility systems within or across CSUs; access for subsistence activities; and recognition of state authorities concerning fish, wildlife, navigable waterways, tidelands and submerged lands.

Title XI of ANILCA provides that Alaska’s transportation and utility network is largely undeveloped and future needs for those systems should be identified through a cooperative effort involving the state and federal government, with public participation. The development of any transportation or utility corridors should be established to minimize any adverse impacts to the environment. Additionally, ANILCA requires drafting a timely environmental impact statement for a proposed utility or transportation corridor, prepared by all federal agencies with which the application was filed.
3. Native Allotments
Lessees must comply with applicable federal law concerning Native allotments. Activities proposed in a plan of operations must not unreasonably diminish the use and enjoyment of lands within a Native allotment. Before entering lands subject to a pending or approved Native allotment, lessees must contact the Bureau of Indian Affairs (BIA) and the BLM and obtain approval to enter.

4. Applicable Laws and Regulations
In addition to existing laws and regulations applicable to oil and gas activities, DO&G requires that leases be subject to all applicable state and federal statutes and regulations in effect on the effective date of the lease. Leases will also be subject to all future laws and regulations placed in effect after the effective date of the leases to the full extent constitutionally permissible and will be affected by any changes to the responsibilities of oversight agencies.

D. Local Government Powers

1. North Slope Borough
Under the authority of Title 29 of the Alaska Statutes, the North Slope Borough (NSB) is responsible for planning and zoning through the implementation of Title 19 of the NSB Municipal Code (NSBMC). Title 19: Zoning is administered through the NSB permitting program and aims to ensure future growth according to values of borough residents, secure benefits from development, and address negative impacts of oil and gas development (NSB 2014). All oil and gas development activities must be consistent with the management policies of Title 19 and the NSB Comprehensive Plan (NSB 2019).

Title 19 establishes land use regulations and created the Department of Planning and Community Services. This department is responsible for administering the NSB’s planning and zoning ordinances, ensuring compliance with local, state, and federal law regarding land use, and provides review and comment on development issues borough-wide. Title 19 also sets out the zoning districts for the NSB. The Sale Area is completely contained within the NSB and is zoned as Conservation and Transportation Corridor districts. Requirements for work conducted within the NSB are outline in Title 19 (NSBMC § 19.70).

Project proponents must consult with NSB staff and the residents of the nearest villages in the design and planning stages of project to incorporate contemporary and traditional local knowledge regarding activities in the Sale Area. Area wide and transportation corridor development policies are addressed in NSBMC § 19.70.050 and § 19.70.060, respectively.

E. References


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</tr>
<tr>
<td>Table 8.6.</td>
<td>Household descriptions of foods eaten in last 12 months, 2014</td>
<td>8-34</td>
</tr>
<tr>
<td>Table 8.7.</td>
<td>Number of responses identifying oil and gas impacts to caribou harvest activities in 2016</td>
<td>8-35</td>
</tr>
<tr>
<td>Table 8.8.</td>
<td>Environmental issues for Sale Area communities in 2016</td>
<td>8-36</td>
</tr>
</tbody>
</table>
Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Decades of oil and gas activities on the North Slope have had a range of effects on the environment, fish and wildlife, subsistence uses, cultural resources, and other uses. As effects are understood, measures are taken to prevent and mitigate reasonably foreseeable effects resulting from oil and gas activities. The Division of Oil and Gas (DO&G) has cooperatively developed general mitigation measures that lessees must follow to minimize pollution and habitat degradation, and disturbances to fish and wildlife, subsistence users, and communities adjacent to the Foothills Areawide lease sale area (Sale Area). Further, post-disposal authorizations may be subject to additional project-specific and site-specific mitigation measures that the director deems necessary to protect the state’s interest. Despite these protective measures, effects may occur. In accordance with AS 38.05.035(g), the reasonably foreseeable cumulative effects of post-disposal oil and gas activities and brief summaries of measures to mitigate those effects are presented in this chapter. See Chapter Nine for a complete listing of the mitigation measures for the Sale Area.

Alaska statutes specify that speculation about possible future effects is not required (AS 38.05.035(h)). Many studies describe the individual and cumulative effects of oil and gas activities on: fish and wildlife habitat, populations, and uses; subsistence uses; historic and cultural resources; fiscal effects; and effects on municipalities and communities. Potential cumulative effects are considered and discussed below as required by AS 38.05.035(g).

A. Introduction

Under AS 38.05.035(g)(1)(B)(vi), the director is required to consider and discuss the reasonably foreseeable cumulative effects of post-disposal oil and gas activities on the Sale Area including: effects on fish and wildlife habitat and populations; subsistence and other uses; and historic and cultural resources. Under AS 38.05.035(g)(1)(B)(ix), the director is required to consider and discuss facts material to the reasonably foreseeable fiscal effects of the lease sale on the state and affected municipalities and communities. The director must also consider and discuss facts material to the reasonably foreseeable effects of exploration, development, and production of oil and gas, or gas only, on municipalities and communities within or adjacent to the lease sale area under AS 38.05.035(g)(1)(B)(x).

Until oil and gas leases are issued and discoveries are made, the director cannot predict if or when post-disposal oil and gas activities might occur, or the type, location, duration, or level of those potential activities. Strategies and methods used to explore for, develop, produce, and transport petroleum resources will vary, depending on factors unique to the individual area, lessee, operator, or discovery. If a commercially viable resource is found, development will require construction of one or more drill sites. If commercial quantities of oil, gas, or both are located, construction of pipelines would be likely, and additional production and transportation facilities may also be necessary. New roads may be required, and machinery, laborers, and housing would be transported to and located at or near the project sites.

The lease sale and issuance period itself is not expected to have any effects other than to provide initial revenue to the state and granting a lessee rights to explore for and produce oil and gas. Oil and gas activities could affect terrestrial and freshwater habitats; fish and wildlife populations; and
Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

their uses in the Sale Area. These activities could include seismic surveys related to exploration, development, and production of petroleum resources; collection of environmental, cultural, and other data; excavation of material sites; construction and use of support facilities such as gravel pads, staging areas, roads, airstrips, pipelines, housing, processing facilities, and flow stations; transportation of machinery and labor to the leased area; and construction of drill sites and ongoing production activities.

In addition to the mitigation measures in Chapter Nine, all oil and gas activities are subject to local, state, and federal statutes, regulations, and ordinances, some of which are listed as regulatory requirements in this chapter and some of which are discussed in Chapter Seven. Additional project-specific and site-specific mitigation measures may be required by other regulatory agencies, in response to public comments received during review of the proposed activity or as deemed necessary. Mitigation measures listed in 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 Chapter Two.

The scope of this administrative review and preliminary finding addresses only the reasonably foreseeable, significant effects of the uses proposed to be authorized by the disposal of state land (AS 38.05.035(e)(1)(A)).

B. Reasonably Foreseeable Cumulative Effects on Air

Oil and gas exploration, development, and production activities and equipment produce emissions have the potential to affect air quality. Combustion emissions are generated by construction equipment, transport trucks, vehicles, drilling rigs, and compressor engines. Fugitive dust and particulate matter can be generated by traffic as well as combustion. Methane and other volatile organic compounds can be released during flaring and venting, and may also escape through leaks in piping and equipment (NPC 2011; Alvarez and Paranhos 2012).

Emissions from oil and gas activities typically include carbon monoxide; nitrogen oxides; sulfur dioxide; coarse and fine particulate matter; volatile organic compounds; ozone; and greenhouse gases including carbon dioxide, methane, and nitrous oxide (Allison and Mandler 2018a). In addition to these air pollutants, small quantities of hazardous air pollutants including hydrogen sulfide, benzene, and formaldehyde may also be released (Alvarez and Paranhos 2012). The US Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (ADEC), Division of Air Quality require industries with emissions that may affect air quality to control and reduce their air emissions such that Alaska and national ambient air quality standards are maintained. The oil and gas industry has developed best management practices and implemented control technologies where appropriate to meet regulatory requirements (NPC 2011).

1. Potential Cumulative Effects on Air Quality

The main air pollutants of concern in Alaska are fine and coarse particulate matter, followed by wildland fire monitoring, carbon monoxide, rural community and tribal village monitoring, lead, and ozone (ADEC 2020a). Emissions from combustion are the primary source of fine particulates. ADEC requires an annual emissions inventory report for sources with potential emissions at or above 2,500 tons per year of sulfur oxide, nitrogen oxide, or carbon monoxide, and for annual emission of 250 tons for volatile organic compounds, ammonium, and for coarse and fine particulate matter (ADEC 2017b). Fuel-burning equipment, machinery, and vehicles; oil and gas storage, handling, and transport; venting, flaring, and spills; and construction and traffic generated fugitive dust from oil and gas activities could cumulatively affect air quality within the Sale Area.
The air quality on the North Slope generally does not exceed national and Alaska ambient air quality standards, with few major pollution sources located near communities and good wind dispersion. Major oil and gas industrial air pollutant sources on the North Slope comply with national and Alaska ambient air quality standards (Table 8.1). Dust (PM$_{10}$) at Nuiqsut in the fourth quarter of 2019, exceeded the standard on October 27, 2019, when strong easterly winds likely increased wind-blown dust. This single measurement exceeding the 150 µg/m$^3$ standard, however, does not constitute a violation which is based on an average of exceedances over three years with no exceedances in either 2017 or 2018 (SLR 2020).

Table 8.1.—Ambient concentrations of air pollutants at North Slope industrial sites.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_2$ — Nitrogen dioxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-hr</td>
<td>100 ppb</td>
<td>32.4</td>
<td>31.8</td>
<td>49.65</td>
<td>21.4</td>
<td>31.5</td>
<td>83.67</td>
<td>42.2</td>
</tr>
<tr>
<td>Annual</td>
<td>55 ppb</td>
<td>1.0</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>2.7</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>SO$_2$ — Sulfur dioxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-hr</td>
<td>75 ppb</td>
<td>2.0</td>
<td>3.5</td>
<td>2.3</td>
<td>2.3</td>
<td>4.0</td>
<td>9.4</td>
<td>1</td>
</tr>
<tr>
<td>3-hr</td>
<td>0.5 ppm</td>
<td>0.0020</td>
<td>0.0</td>
<td>0.0025</td>
<td>0.0023</td>
<td>0.0029</td>
<td>0.0064</td>
<td>0.0120</td>
</tr>
<tr>
<td>24-hr</td>
<td>0.14 ppm</td>
<td>0.0019</td>
<td>0.00</td>
<td>0.0016</td>
<td>0.0011</td>
<td>0.0013</td>
<td>0.0088</td>
<td>0.0045</td>
</tr>
<tr>
<td>Annual</td>
<td>0.030 ppm</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0004</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0056</td>
<td>0.0005</td>
</tr>
<tr>
<td>CO — Carbon monoxide</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-hr</td>
<td>35 ppm</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0.3</td>
<td>--</td>
<td>1</td>
<td>1.45</td>
</tr>
<tr>
<td>8-hr</td>
<td>9 ppm</td>
<td>0</td>
<td>1</td>
<td>1.5</td>
<td>0.2</td>
<td>--</td>
<td>1</td>
<td>0.569</td>
</tr>
<tr>
<td>O$_3$ — Ozone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-hr</td>
<td>0.070 ppm</td>
<td>0.050</td>
<td>0.049</td>
<td>0.048</td>
<td>0.051</td>
<td>0.046</td>
<td>0.046</td>
<td>0.046</td>
</tr>
<tr>
<td>PM$_{10}$ — Particulate matter &lt;10 microns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-hr</td>
<td>150 µg/m$^3$</td>
<td>20</td>
<td>200*</td>
<td>84.5</td>
<td>39</td>
<td>--</td>
<td>43.3</td>
<td>20.0</td>
</tr>
<tr>
<td>PM$_{2.5}$ — Particulate matter &lt;2.5 microns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-hr</td>
<td>35 µg/m$^3$</td>
<td>7</td>
<td>7</td>
<td>15.1</td>
<td>7</td>
<td>--</td>
<td>12.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Annual</td>
<td>12 µg/m$^3$</td>
<td>2.3</td>
<td>1.7</td>
<td>4.2</td>
<td>2.8</td>
<td>--</td>
<td>3.3</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: (ADEC 2018b; SLR 2020)
Notes: AAAQS = Alaska Ambient Air Quality Standard; NAAQS = National Ambient Air Quality Standard; -- = no data; hr = hour; ppm = parts per million; ppb = parts per billion; µg/m$^3$ = micrograms per cubic meter
*The daily average for PM$_{10}$ exceeded the 150 µg/m$^3$ standard on October 27, 2019.

Local weather conditions influence the dispersal and distribution of air pollutants, and in-air concentrations of volatile organic compounds including benzene, hydrogen sulfide, and formaldehyde, may be present near oil and gas production sites (Macey et al. 2014). While Nuiqsut residents, the community closest to oil and gas development on the North Slope, have expressed concerns over air pollution generated by oil and gas activities; assessments of air quality have generally shown pollutant concentrations well below ambient standards (Table 8.1). The few exceedances of ambient air quality standards for particulates have been linked to natural sources including wind-blown dust and forest fires. Air samples collected for volatile organic compounds at Nuiqsut have not exceed air quality standards and failed to detect compounds associated with crude oil development. Investigations of Nuiqsut clinic visits for respiratory conditions identified no relationship between air pollution and respiratory illness (BLM 2017).
A recently completed emissions inventory summarizes oil and gas emissions for the North Slope (Table 8.2). Several cumulative effects analyses for oil and gas developments across the North Slope have been completed that generally agree that cumulative air quality impacts from ongoing and projected oil and gas activities are not likely to result in significant air quality deterioration as measured by exceedances in ambient air quality standards (Fields Simms et al. 2018). Inventories identify onshore sources, especially onshore production, as contributing between 96 and 99 percent of the annual emissions of pollutants (Fields Simms et al. 2018). Projected onshore emissions based on a development scenario at three new onshore facilities, the Liberty Development, new onshore pipeline construction and operations, new support facilities for offshore developments, and a doubling of Trans-Alaska Pipeline System (TAPS) throughput based on production from four Beaufort Sea and two Chukchi Sea Outer Continental Shelf oil and gas platforms. Based on this scenario, projected onshore developments represent incremental increases of 36 percent for nitrogen oxides, 28 percent for sulfur dioxide, 31 percent for volatile organic compounds, and 53 percent for carbon monoxide compared to baseline North Slope emissions (Table 8.2).

Table 8.2.—Baseline and projected North Slope oil and gas emissions.

<table>
<thead>
<tr>
<th>Pollutant (tons/year)</th>
<th>NO\textsubscript{x}</th>
<th>SO\textsubscript{2}</th>
<th>VOC</th>
<th>CO</th>
<th>PM\textsubscript{10}</th>
<th>PM\textsubscript{2.5}</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline Emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onshore Seismic Surveys</td>
<td>114.1</td>
<td>9.5</td>
<td>2.7</td>
<td>31.0</td>
<td>10.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Onshore Exploratory Drilling</td>
<td>1,388.2</td>
<td>42.1</td>
<td>354.2</td>
<td>318.0</td>
<td>19.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Onshore Production</td>
<td>42,260.1</td>
<td>1,049.0</td>
<td>1,707.2</td>
<td>8,967.5</td>
<td>1,168.6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Onshore Total</td>
<td>45,811.7</td>
<td>1,243.1</td>
<td>2,918.4</td>
<td>14,073.4</td>
<td>35,647.7</td>
<td>4,774.5</td>
<td>0.244</td>
</tr>
<tr>
<td>Offshore Total</td>
<td>1,816.3</td>
<td>38.2</td>
<td>106.0</td>
<td>248.6</td>
<td>35.8</td>
<td>27.2</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Baseline Totals</strong></td>
<td>47,628.0</td>
<td>1,281.3</td>
<td>3,024.4</td>
<td>14,322.0</td>
<td>35,683.0</td>
<td>4,801.7</td>
<td>0.250</td>
</tr>
<tr>
<td><strong>Projected Emissions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onshore Total</td>
<td>17,365.4</td>
<td>364.0</td>
<td>945.2</td>
<td>7,528.5</td>
<td>971.5</td>
<td>898.4</td>
<td>0.021</td>
</tr>
<tr>
<td><strong>Projected Increase (percent)</strong></td>
<td>36.5%</td>
<td>28.4%</td>
<td>31.3%</td>
<td>52.6%</td>
<td>2.7%</td>
<td>18.7%</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

Source: (Fields Simms et al. 2018)
Notes: NO\textsubscript{x} = Nitrogen Oxides; SO\textsubscript{2} = Sulfur Dioxide; VOC = Volatile Organic Compounds; PM\textsubscript{10} = Particulate Matter ≤10 micrometers; PM\textsubscript{2.5} = Particulate Matter ≤2.5 micrometers; Pb = Lead.

Oil and gas produced from the North Slope accounted for approximately 97 percent of oil and 79 percent of gas production in Alaska, accounting for an estimated 85 percent of oil and gas industry greenhouse gas emissions in 2015 (ADEC 2018a; DO&G 2018b). Baseline and projected North Slope oil and gas emissions for greenhouse gases and other hazardous air pollutants are summarized in Table 8.3. There are currently two permitted major stationary sources within the Sale Area, Pump Station 3 and Pump Station 4 (ADEC 2020b). Combined annual emissions from Pump Stations 3 and 4 from 2010 to 2019 were 459 tons of carbon monoxide, 118 tons of nitrogen oxides, 56 tons of volatile organic compounds, and 6 tons of sulfur dioxide (ADEC 2020f).
### Table 8.3.—Baseline and projected North Slope oil and gas emissions for greenhouse gases and other pollutants.

<table>
<thead>
<tr>
<th>Pollutant (tons/year)</th>
<th>Greenhouse Gases</th>
<th>Other Pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO₂</td>
<td>CH₄</td>
</tr>
<tr>
<td><strong>Baseline Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onshore</td>
<td>13,570,837</td>
<td>8,792.4</td>
</tr>
<tr>
<td>Offshore</td>
<td>139,983</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>13,710,820</td>
<td>8,793.2</td>
</tr>
<tr>
<td><strong>Projected Emissions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onshore</td>
<td>18,371,080</td>
<td>26,602.2</td>
</tr>
<tr>
<td>Offshore Beaufort</td>
<td>1,293,500</td>
<td>52,375.3</td>
</tr>
<tr>
<td>Total</td>
<td>19,664,580</td>
<td>78,977.5</td>
</tr>
</tbody>
</table>

Source: (Fields Simms et al. 2018)

Notes: CO₂ = Carbon Dioxide; CH₄ = Methane; N₂O = Nitrous Oxide; CO₂e = Carbon Dioxide Equivalent; HAP = Hazardous Air Pollutants; H₂S = Hydrogen Sulfide, NH₃ = Ammonia.

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**Figure 8.1.—Combined Alyeska Pump Station 3 and 4 emissions in the Sale Area.**

Source: (ADEC 2020f)
Depending on the season, clouds can cool or warm near-surface air, modulating the arctic climate radiation budget. Alteration of the aerosol-cloud-radiation feedback loop has implications for accelerated climate change. Arctic haze during winter and spring is generally attributed to long-range transport of pollutants including aerosol particles from mid-latitudes, while summer and fall aerosols contain contributions from marine and terrestrial biological activity, sea spray, and anthropogenic sources (Kolesar et al. 2017). While not reaching levels that exceed ambient air quality standards, emissions from Prudhoe Bay oil fields are a source of nucleated aerosol and combustion aerosol in localized air masses at and below 1,640 feet above mean sea level (Creamean et al. 2018) that influence local cloud properties (Maahn et al. 2017). In addition, based on backward air mass trajectory analysis, Prudhoe Bay air masses influenced 33 percent of particle growth events that provide cloud condensation nuclei over 160 miles away at Utqiaġvik (Kolesar et al. 2017). However, while local Prudhoe Bay emissions have been demonstrated to influence local cloud properties, the overall spatial extent of this influence may not be significant on a regional (North Slope) scale (Maahn et al. 2017; Creamean et al. 2018).

2. Mitigation Measures and Other Regulatory Protections

Existing and future oil and gas facilities and activities are required to control and limit emissions. Combustion and fugitive emissions are minimized and mitigated by using best management practices and control technologies. Construction and traffic induced fugitive dust is minimized and mitigated by using best management practices such as construction area and road watering.

Emissions associated with routine program activities would increase, although potential cumulative effects to air quality from existing and future oil and gas activities would likely be distributed throughout the region. Maximum concentrations of air pollutants occur close to facilities and disperse with air movements. Existing and future oil and gas activities are required to control emissions and maintain national and Alaska ambient air quality standards.

Industry compliance with federal and state air quality regulations, particularly the Clean Air Act (42 USC §§ 7401-7671), AS 46.03, AS 46.14, and 18 AAC 50 are expected to prevent potential negative cumulative effects on air quality. Additional information regarding air quality regulations and permits can be found in Chapter Seven.

C. Reasonably Foreseeable Cumulative Effects on Water Resources

Oil and gas activities both consume and produce water. Water is used to drill and hydraulically fracture wells, to hydrostatically test pipelines, to process oil and gas, to enhance oil and gas recovery through waterflood, to construct and maintain facilities, and in camps. Water is extracted with and separated from oil and gas during production, sometimes in large quantities (Allison and Mandler 2018b). Activities that may affect water resources within the Sale Area include seismic exploration and overland transport, gravel mining, gravel road and pad construction and maintenance, ice road and ice pad construction, and water withdrawals to support drilling and production. North Slope fields also use large quantities of treated sea water for enhanced oil recovery. Water use is regulated by the Department of Natural Resources (DNR), Division of Mining, Land, and Water (DMLW) to ensure waters maintain the standards to support recreation activities, navigation, water rights, or other substantial public interests. Discharges are regulated by ADEC to ensure protection of Alaska’s waters.
1. Potential Cumulative Effects on Water Resources

National Research Council (NRC 2003) concluded that, “Evidence suggests that no significant changes in seasonal patterns or concentrations of chemicals in lakes and streams have resulted from industrial activities on the North Slope.” However, NRC did find that gravel roads and pads have interrupted sheet flow and stream flows, and that while proper construction and placement of culverts can reduce these effects, they cannot be eliminated (NRC 2003). NRC also cautioned that development in areas where surface water is less abundant could result in different effects than those in the Prudhoe Bay region (NRC 2003). Water resources in the Sale Area differ from those to the north in the Prudhoe Bay region by reduced abundance of deep lakes and ponds, more developed drainage due to increased topographic relief, and the presence of perennial springs (Figure 8.2).

Potential cumulative effects on water quality could include contamination from discharge of drilling muds, cuttings, and produced water; increased turbidity from construction of roads, pads, and pipelines; and contamination from inadvertent release from well blowouts or oil or fuel spills. Potential cumulative effects on water distribution could include physical disturbances that alter drainage patterns resulting in upslope impoundments, downslope drying, or diversion of water between watersheds. Potential cumulative effects on water quantity could include reduced availability of water from lakes, ponds, rivers; and ground water from industrial water use for construction and maintenance of ice roads and pads; for dust suppression on gravel roads and pads; for mixing drilling muds; for potable, domestic, and fire suppression water supplies; and for industrial process and cooling water.

a. Surface Water

Oil and gas exploration, development, and production generally requires the construction and continued use of support facilities such as roads, production pads, pipelines, tank farms, and distribution terminals. In addition to covering tundra vegetation, facility construction may require site preparation, placement of gravel fill, and impoundment and diversion of surface water that may alter water quality and distribution through increased erosion, storm water runoff, and altered hydrology or circulation. Turbidity is the measure of particulate matter suspended in water. Turbidity of surface waters increases when sediment-laden runoff from pipeline construction or repair or facility construction flows into surface waters. Erosion from ground disturbing activities can result in elevated turbidity and increased sedimentation of nearby streams and lakes.

Discharge of drilling fluids, cuttings, and produced water is regulated and is usually accomplished by annular or underground injection. Produced water must be either re-used or sent to disposal wells. In either case some treatment may be required because produced water usually contains salts and residual oil and cannot be safely released at the surface (Allison and Mandler 2018b). On the North Slope, produced water is generally re-injected into the formation for enhanced oil recovery, but may also be sent to disposal wells. Discharge of drilling fluids, cuttings, and produced water to surface waters and wetlands is prohibited on the North Slope, including the Sale Area.

Currently there are 49 active wastewater discharge authorizations under ADEC’s Alaska Pollutant Discharge Elimination System (APDES) general permit for North Slope oil and gas exploration, production, and development facilities (AKG332000; ADEC 2020g). This general permit authorizes discharges of graywater, gravel pit dewatering, excavation dewatering, hydrostatic test water, construction stormwater, industrial stormwater, mobile spill response, and secondary containment dewatering. Since a general permit was developed in 2012, there have been no exceedance of the permitted graywater discharge level of up to 5,000 gallons per day, with less than 7 percent exceedance for total suspended solids (TSS), and less than 10 percent exceedance for 5-day biochemical oxygen demand (BOD5). For facilities with no mixing zone, the exceedance rate
Figure 8.2.—Springs, unfrozen winter water, and water usage in the Sale Area.

Source: (Kane et al. 2013; Grunblatt and Atwood 2014)
for fecal coliforms was 37 percent, although application of a mixing zone would have reduced this
to two incidents (ADEC 2017a). No waters on the North Slope or within the Sale Area are currently
listed by ADEC as impaired (ADEC 2020c).

Accidental spills of fuel, oil, lubricants, or other hazardous chemicals could affect surface waters in
the Sale Area. Of the 29 known contaminated sites that occur in the Sale Area, all but a few are
associated with oil and gas or activities, and all but one occurred from incidents more than 20 years
ago. The three active contamination sites in the Sale Area include a legacy oil exploration site and
spills associated with TAPS (ADEC 2020e). At Happy Valley Camp, multiple contaminants remain
from spills that occurred during pipeline construction in the late 1970s. Although the site is still
considered active, surface water sampling results from 2015, 2016, and 2017 did not contain
contaminant concentrations above ADEC surface water quality standards. At Alyeska Pump Station
4, crude oil contamination was exposed about 12 feet below the ground surface while excavating a
section of the pipeline deadleg for reaplication of insulation. The suspected source of this
contamination was a spill that occurred from a seal failure in 1984. An additional 11 contaminated
sites in the Sale Area are considered cleanup complete with institutional controls to prevent
exposure of residual contamination, with the remaining 15 sites considered closed with no further
action required (ADEC 2020e). Spills and contaminated sites in the Sale Area and spill and leak
prevention and response are addressed further in Chapter Six.

Surface waters are much less abundant in the Sale Area than on the coastal plain to the north and
many lakes and ponds are shallow, freezing solid in winter (Grunblatt and Atwood 2014). This can
complicate finding sufficient ice and unfrozen water for winter ice-road or pad construction. The
distribution of unfrozen water in winter is shown in Figure 8.2. Surface water use for exploration,
development, production, and transportation of oil and gas may result in cumulative effects to
availability of surface waters. Surface water use is regulated through temporary water use permits
and water rights. There are 11 active temporary water use authorizations for 29 locations and
2 surface water rights totaling 33 million gallons per year in the Sale Area (Table 8.4; Figure 8.2),
primarily within the Sagavanirktok River watershed.

Because of the potential for the oil and gas industry to use large quantities of water in the
Sagavanirktok River watershed, Alaska Department of Game and Fish (ADF&G) reserved
minimum instream flows to support fish and wildlife habitat, migration, and production in the reach
of the Sagavanirktok River in the Sale Area (Figure 8.3). Based on gauging station data near Pump
Station 3, minimum daily flows fell below ADF&G’s reservation at least once on 34 percent of
dates (126 of 365 days) but mean daily flows did not fall below ADF&G’s reservation during the
10-year period from 2010 to 2019. Although there is a potential for water use conflicts in this
watershed, to date surface water withdrawals have not been noted as decreasing Sagavanirktok
River instream flows below ADF&G’s reservation levels.
Table 8.4.—Surface water use authorizations in the Sale Area.

<table>
<thead>
<tr>
<th>File</th>
<th>No. Sites</th>
<th>Permit Holder</th>
<th>Authorized Amounts</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gallons per Day</td>
<td>Gallons per Year</td>
</tr>
<tr>
<td>Temporary Water Use Authorizations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TWUA A2018-44</td>
<td>1</td>
<td>ADOT – NRO</td>
<td>150,000</td>
<td>2,000,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA A2018-45</td>
<td>5</td>
<td>ADOT – NRO</td>
<td>750,000</td>
<td>7,500,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA A2018-46</td>
<td>5</td>
<td>ADOT – NRO</td>
<td>750,000</td>
<td>9,900,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA A2018-47</td>
<td>5</td>
<td>ADOT – NRO</td>
<td>750,000</td>
<td>7,020,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA A2018-69</td>
<td>1</td>
<td>ADOT – NRO</td>
<td>150,000</td>
<td>1,000,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA A2018-71</td>
<td>1</td>
<td>ADOT – NRO</td>
<td>150,000</td>
<td>2,000,000 Construction, dust control</td>
</tr>
<tr>
<td>TWUA P2016-03</td>
<td>2</td>
<td>Alyeska – TAPS</td>
<td>60,000</td>
<td>NA Maintenance</td>
</tr>
<tr>
<td>TWUA P2017-01</td>
<td>5</td>
<td>Alyeska – TAPS</td>
<td>90,000</td>
<td>600,000 Maintenance, dust control, ice</td>
</tr>
<tr>
<td>TWUA P2018-01</td>
<td>2</td>
<td>Alyeska – TAPS</td>
<td>30,000</td>
<td>NA Maintenance, dust control, ice</td>
</tr>
<tr>
<td>TWUA P2018-18</td>
<td>1</td>
<td>Alyeska – TAPS</td>
<td>35,000</td>
<td>2,100,000 Maintenance, dust control, ice</td>
</tr>
<tr>
<td>TWUA P2019-01</td>
<td>1</td>
<td>Alyeska – TAPS</td>
<td>15,000</td>
<td>900,000 Airstrip dust control</td>
</tr>
<tr>
<td>Surface Water Rights</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAS 23840</td>
<td>1</td>
<td>Alyeska – TAPS</td>
<td>30,000</td>
<td>104,272 Maintenance, construction</td>
</tr>
<tr>
<td>LAS 26680</td>
<td>1</td>
<td>Private</td>
<td>100</td>
<td>Domestic water</td>
</tr>
<tr>
<td>Totals</td>
<td>31</td>
<td></td>
<td>2,960,100</td>
<td>33,020,000</td>
</tr>
</tbody>
</table>

Source: (DNR – Land Administration System records)
Notes: TWUA = Temporary Water Use Authorization; LAS = Land Administration System; ADOT = Alaska Department of Transportation; NRO = Northern Region Office; Alyeska = Alyeska Pipeline Service Company; TAPS = Trans-Alaska Pipeline System.

Figure 8.3.—Sagavanirktok River instream flow reservations with minimum and mean daily flow rates near Pump Station 3 during 2010 to 2019.

Source: (DNR 2020; USGS 2020)
b. Ground Water

Oil and gas exploration, development, and production may impact ground water through spills at the surface that penetrate soils to reach shallow ground water, leaks from wells, cracks in overlying formations that allow movement of fluids or gas into an aquifer from wells, or through industrial use of water from water wells (Allison and Mandler 2018b). The contaminated site at Happy Valley Camp resulted from spills that occurred during pipeline construction in the late 1970s. Although this site remains active, ground water sample results from 2015, 2016, and 2017 did not contain contaminant concentrations above ADEC groundwater cleanup levels (ADEC 2020e). Spills are required to be reported and contaminated materials removed to prevent contaminate from reaching shallow ground water.

Oil and gas wells generally have multiple casing layers and cement barriers to prevent oil, water, or gas from leaking into aquifers or other surrounding rock formations. Oil or gas wells may leak if the steel casing or cement are poorly constructed or damaged (Allison and Mandler 2018b). Disposal wells are also a potential source of ground water contamination. These wells are required to show isolation of the receiving formation from surrounding formations including any aquifers and must meet strict construction or conversion standards and regular testing and inspection (EPA 2019). There are 12 Class I non-hazardous waste disposal wells on the North Slope, with none in the Sale Area (EPA 2020). There are many Class II wells in the North Slope oil fields that are used to inject sea water, produced water, and/or gas for enhanced oil recovery. All oil and gas exploration, production, injection, and disposal wells are required to be isolated from underground sources of drinking water.

Facilities generally require potable water for camps and year-round water supplies for maintenance and construction including construction of ice work pads and roads, and road watering for dust suppression. While many water requirements are fulfilled through the use of surface waters as discussed above, in the Sale Area, water for camps and industrial processes are also supplied by water wells at Pump Stations 3 and 4 and at the Toolik Lake research facility (Table 8.5; Figure 8.2).

Several springs occur along the eastern Sale Area boundary (Kane et al. 2013), and while unlikely, excessive withdrawal of groundwater could potentially reduce discharge from perennial springs. Monthly water use data reports for 2003 to 2019 for one water well at Pump Station 3 (LAS 23974) indicates that annual withdrawal values average about 50 percent of the permit limit amount and exceeded the total allowable limit in only 1 year, 2006 (DMLW 2020). There are no data indicating that current groundwater usage rates influence perennial spring discharge in the region or hyporheic flow (Boano et al. 2014) in the adjacent Sagavanirktok River.
Table 8.5.—Subsurface water use authorizations in the Sale Area.

<table>
<thead>
<tr>
<th>File</th>
<th>Well Depth (feet)</th>
<th>Permit Holder</th>
<th>Authorized Amounts</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWUA P2017-05</td>
<td></td>
<td>Alyeska – TAPS</td>
<td>30,000</td>
<td>PS4 – existing well</td>
</tr>
<tr>
<td>LAS 23974</td>
<td>39.9</td>
<td>Alyeska – TAPS</td>
<td>12,500</td>
<td>2,228,821</td>
</tr>
<tr>
<td>ADL 64152</td>
<td>171</td>
<td>Alyeska – TAPS</td>
<td>7,500</td>
<td>2,737,500</td>
</tr>
<tr>
<td>ADL 64153</td>
<td>30.0/39.1</td>
<td>Alyeska – TAPS</td>
<td>7,500</td>
<td>2,737,500</td>
</tr>
<tr>
<td>LAS 24226</td>
<td>118</td>
<td>UAA</td>
<td>8,750</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>66,250</td>
<td>7,703,821</td>
</tr>
</tbody>
</table>

Source: (DNR – Land Administration System records)
Notes: TWUA = Temporary Water Use Authorization; LAS = Land Administration System; ADL = Alaska Division of Lands; Alyeska = Alyeska Pipeline Service Company; TAPS = Trans-Alaska Pipeline System; UAA = University of Alaska-Anchorage, Facilities and Land Management; PS3 = Pump Station 3; PS4 = Pump Station 4.

2. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could result in adverse effects to the limited water resources in the Sale Area. Adverse effects on water resources would be avoided or minimized to the extent possible. Most water resource effects would result from oil and gas development and production activities that include construction of roads, stream-crossings, and development of permanent facilities with discharges, runoff, and water use being the major contributors. Potential effects include changes in surface drainage due to construction of roads and pads, loss of wetlands and associated chemical and hydrologic functions, gravel mine development, water use for camps and production facilities, and the increased risk of spills and leaks.

Oil and gas facility wastewater discharges are regulated through ADEC's APDES program (ADEC 2020d). Existing and new facilities are required to control and manage stormwater and snow melt runoff during construction and operation to avoid and minimize potential contamination. Wetlands and shallow groundwater protection is accomplished through regulation of contaminated sites, storage tanks, underground injection wells, spill response, and specific waste disposal activities under state and federal programs. Because of permitting requirements for proper disposal, water quality is not expected to be impacted by drilling muds, cuttings, produced waters, or wastewater discharges associated with oil and gas exploration, development, and production. Permanent roads and pads, and large-scale excavation or fill of wetlands will require a Clean Water Act Section 404 permit and/or a Rivers and Harbors Act Section 10 permit.

DMLW water use permits and water rights may contain stipulations on water use and specify withdrawal limits to ensure the use of the resource is consistent with the public interest. Water use permits may also be subject to conditions, including suspension and termination of exploration activities, to protect fish and wildlife habitat, public health, or the water rights of other persons. Before a permit to appropriate water is issued, DNR considers local demand and may require applicants to conduct lake recharge studies.
Measures in this best interest finding, along with regulations imposed by state, federal, and local agencies are expected to avoid, minimize, and mitigate potential effects. Risk of oil spills, spill avoidance, and spill response planning are discussed further in Chapter Six. A complete listing of mitigation measures can be found in Chapter Nine.

D. Reasonably Foreseeable Cumulative Effects on Freshwater Habitats and Fish

Potential oil and gas activities that could have cumulative effects on freshwater habitats and fish within the Sale Area include seismic surveys, construction of production and support facilities, drilling and production activities, discharges from well drilling and production, transportation, and gas blowouts or oil spills. Some potential cumulative effects of these activities include physical changes and disturbance that could alter watersheds, waterbodies, and wetlands; habitat availability and suitability; and behavior of fish (NRC 2003).

Existing and future oil and gas extraction carry the risk of fuel and oil spills and leaks, both small and large within and outside of the boundaries of the Sale Area. Localized effects from small spills are generally limited to the direct damage to habitat and fish in the immediate vicinity representing a very small effect in relation to habitat and fish on the North Slope. Effects from spills become dispersed and potentially more significant when they occur within or near open water because oil is generally more difficult to contain and recover from water than from land or ice. A spill that contaminates groundwater could also result in impacts to ponds, lakes, streams, and rivers.

1. Potential Cumulative Effects on Freshwater Habitats and Fish

Linear features constructed for oil and gas exploration and development, such as roads, seismic lines, and pipelines cross lakes, rivers, and streams in the Sale Area. Oil and gas activities may affect freshwater habitats and fish through increased sediment transport, sedimentation, pressure impacts from the use of explosives for seismic surveys or gravel extraction, water withdrawal, blockage of stream flow and fish passage, removal of riparian vegetation, increased access and fisheries exploitation, and contaminant spills (Cott et al. 2015). Impacts can be direct through physical or chemical damage to fish or eggs, or indirect through habitat loss and degradation (Cott et al. 2015). Oil and gas activities can have cumulative effects that can be exacerbated by stressors such as a changing climate (Cott et al. 2015).

Less than 1 percent of the Sale Area contains ponds and lakes, and about 1.5 percent of the Sale Area is covered by riverine habitats between the Colville River and the Canning River (see Table 4.2). Some freshwaters in the Sale Area support anadromous and resident fishes and are important for spawning, rearing, overwintering, and migration habitat. Waters within the Sale Area are used by whitefish, arctic grayling, Pacific salmon, Dolly Varden, arctic char, lake trout, and burbot that support subsistence and sport fisheries as discussed in Chapter Four and Chapter Five.

a. Seismic Surveys

Potential cumulative effects from seismic surveys could occur through direct impacts to fish and eggs or through habitat degradation at stream crossings. Deep pools and springs in the Sale Area provide spawning and overwintering habitat for Dolly Varden (Winters 2000; Giefer and Blossom 2020). Winter seismic surveys across spawning and overwintering habitats have the potential to impact eggs or alevins, and fish in the Sale Area (Figure 8.4).
Chapter Eight: Reasonably Foreseeable Effects of Leasing and Subsequent Activity

Figure 8.4.—Dolly Varden and chum salmon spawning and overwintering in the Sale Area.

Source: (Winters 2000; Giefer and Blossom 2020)
Fish hear through the effects of particle motion in water. Generally, fishes with swim bladders that also allow for sound pressure detection, such as salmonids, have lower sound pressure thresholds (55 to 83 decibels [dB] reference level in water [re] 1 micropascal [µPa]) and respond at higher frequencies (200 hertz [Hz] to 3 kilohertz [kHz]) than fishes such as sharks and rays that have thresholds between 78 and 150 dB re 1µPa and detect frequencies below 100 Hz to 1 kHz (Carroll et al. 2017). Where particle acceleration thresholds have been measured fish showed threshold values between 30 and 70 dB re 1 micrometer per square second (µm/s²) (Carroll et al. 2017).

The acoustic energy from seismic airguns (peak sound pressure levels as high as 230 dB 1µPa at 1 meter from the source) has been found to produce threshold shifts in hearing in some freshwater fish, although hearing was recovered within 24 hours and the ear structures and sensory epithelia showed no damage (Popper et al. 2005; Song et al. 2008). Onshore seismic surveys are conducted using vibroseis which imparts lower energy than airgun pulses. An evaluation of potential injury and behavioral effects of vibroseis across overwintering fish, with a possible maximum overpressure as high as 201 dB re 1µPa at the source, found no mortality or serious injury and that behavioral responses were brief and limited to the time of operation of the equipment (Morris and Winters 2005). Behavioral flight responses were vigorous, however, and could have energetic consequences for wintering fish. Best management practices include avoidance or limiting exposure to a short time frame with minimal delays between seismic shots (Morris and Winters 2005).

Seismic vehicles, especially camp-move trails, crossing stream banks can damage banks and riparian vegetation leading to increases in input of fine sediment to streams that can smother fish eggs and reduce primary and secondary productivity that can contribute to overall reduced growth and survival of fish. While riparian shrublands and Dryas river terrace sites are susceptible to severe damage from seismic vehicles, these sites appear to be capable of good vegetation recovery even after severe initial damage, likely because the sand and gravel sediments have little excess ice (Jorgenson et al. 2010). Similarly, although tall shrub-herb riparian vegetation was found to decrease in vascular plant cover primarily through breakage of the dominate shrubs, community composition was not significantly impacted, and these communities appeared relatively resistant to winter seismic disturbance (Kemper and Maedonald 2009). Camp moves are the most damaging aspect of seismic surveys to tundra vegetation (Jorgenson et al. 2010; Walker et al. 2019). With implementation of best management practices, minor to no long-term cumulative effects on freshwater habitats and fish from seismic surveys are expected.

b. Exploration, Development, and Production

Oil and gas exploration, development and production may require the construction and continued use of support facilities such as roads, production pads, pipelines, tank farms, and distribution terminals. Facility construction may require site preparation, placement of gravel fill, and impoundment and diversion of surface water that may alter aquatic habitats through increased erosion, storm water runoff, and altered hydrology. Potential cumulative effects from oil and gas activities on freshwater habitats include increased turbidity from construction of roads, pads, and pipelines; blockage of fish passage; contamination from discharges of wastewater and stormwater runoff; and contamination from inadvertent releases of fuel, oil, or other hazardous materials. Potential cumulative effects on water availability for fish and wildlife include water use from lakes, ponds or streams for construction and maintenance of ice roads and pads; for dust suppression on gravel roads and pads; for mixing drilling muds; for potable, domestic, and fire suppression water supplies; and for industrial process and cooling water (NRC 2003).

Activities associated with oil and gas exploration and development, such as gravel removal, heavy equipment operations, and siting of support facilities could contribute to increased stream sedimentation and erosion, impede fish passage, alter drainage patterns, and have other negative
effects on freshwater habitats and fish (NRC 2003; Cott et al. 2015). Erosion can increase turbidity and deposit fine sediments in aquatic habitats that can smother spawning areas and incubating eggs, decrease primary productivity and reduce food for aquatic insects and fish (Cott et al. 2015). This can lead to direct mortality, reduced physiological function, and depressed growth rates and reproduction in aquatic organisms (Henley et al. 2000). Secondary effects of road construction and use could include dust deposition, that may reduce photosynthesis and plant growth for adjacent riparian vegetation.

Activities near streams that flow into lake systems may have cumulative effects on the water quality of connected lakes (Trammell et al. 2015). Winter water withdrawals from lakes and rivers can reduce water quality by lowering dissolved oxygen levels, trap or entrain overwintering fish, and reduce connectivity to adjacent waterbodies (Cott et al. 2015; Trammell et al. 2015). Construction of new roads can also facilitate fishing access and the dispersal of invasive aquatic organism (Cott et al. 2015; Trammell et al. 2015). Multiple studies have measured the effects of water withdrawal on water quality under current guidelines with most studies finding no difference between lakes used for water withdrawal and reference lakes (Trammell et al. 2015). Although withdrawal of 10 percent of the volume had no effect on the volume-weighted oxygen concentration or volume of over-wintering habitat in a small lake, withdrawal of 20 percent resulted in a 26 percent reduction in volume-weighted oxygen concentration and a 23 percent reduction in volume of over wintering habitat (Cott et al. 2008). Surface water use is regulated to prevent damage to fish and to fish overwintering habitats.

Improperly sized, installed, and unmaintained stream crossing culverts can restrict fish access to many miles of upstream or downstream spawning, foraging, and overwintering habitats (Morris and Winters 2008; Cott et al. 2015). Between 2004 and 2007, ADF&G assessed over 107 crossing structures on streams and rivers within the North Slope oilfields. Of these, 29 percent were considered in poor condition with damaged inlet and outlet structures, substantial scour, bank erosion, and instream gravel deposition, and substantial restrictions or complete blockage of fish passage (Morris and Winters 2008). Of 28 culverts in the Sale Area evaluated for fish passage during 2010 and 2011, 6 culverts (21 percent) were rated inadequate and 6 culverts (2 percent) were rated as potentially inadequate for juvenile salmonid passage. Two of the culverts rated potentially inadequate for fish passage were located on TAPS access roads (ADF&G 2020; ADOT&PF 2009). New roads would be required to construct and maintain stream crossings that allow for fish passage, although some issues are likely to remain with older access roads (Morris and Winters 2008). Once specific fish-passage issues are identified, ADF&G may require responsible parties to improve crossings to re-establish fish passage on state lands. Gravel roads and associated gravel mining have resulted in minor cumulative effects by impeding fish movements and altering physical and chemical conditions of fish habitat (Morris and Winters 2008; Ott et al. 2014).

### c. Discharges, Leaks, and Spills

Discharges from oil and gas activities may be intentional, such as permitted discharges regulated by the APDES, or unintentional, such as gas blowouts, leakages, and spills. Discharges, spills, and leaks from oil and gas activities could affect freshwater habitats and fish populations. Permitted graywater discharges can affect water quality with parameters of concern pH, TSS, BOD₅, fecal coliform bacteria, residues, and total residual chlorine. Discharge monitoring reports for permitted North Slope graywater indicate that there have been few exceedances with less than 7 percent exceedance for TSS and 10 percent exceedance for BOD₅ (ADEC 2017a). Of these parameters, BOD₅ has the greatest potential to effect overwintering fish in isolated and ice-covered pools in winter when ice cover prevents exchange of oxygen with the air and fish must survive on the dissolved oxygen in the pool through the winter. No waters on the North Slope or within the Sale Area are currently listed as impaired by ADEC (ADEC 2020c).
Of the 29 known contaminated sites that occur in the Sale Area, all but a few are associated with oil and gas or activities, and all but one occurred from incidents more than 20 years ago. The three active contamination sites in the Sale Area include a legacy oil exploration site and spills associated with the original TAPS construction and a leak at Pump Station 4 in the 1980s (ADEC 2020e). Current standard secondary containment and best management practices for fuel and oil handling and storage would likely have prevented most of these contaminated sites.

Oil, fuel, and associated polycyclic aromatic hydrocarbons are toxic to fish and a spill that affects spawning habitats could kill eggs and impair recruitment (Cott et al. 2015). Sublethal effects and contamination from spills and leaks can reduce productivity and impact subsistence use of fisheries resources. Failure of sumps used to store drilling mud or camp greywater can also be harmful if wastes reach fish bearing waters (Cott et al. 2015). The effects of oil spills on fish and their habitat depend on the timing and location of the spill. Spills into open water are more likely to affect fish than a spill on top of ice that can be easily contained and removed. Spills into lakes may have longer lasting effects than a spill into a large stream or river that is quickly diluted and dispersed. Spills occurring farther upstream in a watershed also place more freshwater habitat at risk than those that occur in lower reaches or along the coast where the contaminants are more readily diluted with the higher volumes of water. Spill and leak prevention and response are addressed in Chapter Six.

2. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on freshwater habitats and fish populations, although cumulative impacts are expected to be localized and minor. Cumulative effects on freshwater habitats and fish would most likely occur through construction and use of permanent roads and gravel mining to build this infrastructure. Gravel roads and gravel mine sites have contributed to impeded fish movements and altered physical and chemical conditions of fish habitat. Mitigation measures in this best interest finding, along with regulations imposed by state, federal, and local agencies are expected to avoid, minimize, and mitigate potential cumulative effects to freshwater habitats and fish populations.

AS 16.05 requires protection of documented anadromous streams from disturbances associated with development. New facilities are required to be located away from lakes and rivers and stream crossing must be designed and maintained to allow fish passage. Any water intake structures in fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must use fish screening devices approved by the ADF&G and withdrawal volumes are regulated to prevent damage to fish wintering habitats. Discharge of drilling muds and cuttings to freshwaters or wetlands is prohibited. Disposal of wastewater into water bodies is prohibited unless authorized by an APDES permit. Best management practices and mitigation including use of ice roads for exploration, perpendicular crossing of waterways by roads and pipelines, appropriately sized culverts and bridges, and siting permanent infrastructure at least 1/2 mile from fish-bearing waterways minimizes the potential for cumulative effects of oil and gas activities in the Sale Area.

Specific mitigation measures for freshwater habitats and fish in this best interest finding address siting facilities 1/2 mile away from Dolly Varden overwintering and/or spawning areas; and ensuring that road and pipeline crossing within 1/2 mile of these areas are not located within overwintering and/or spawning areas, or that the crossing would have no effect on these fish or habitats. A complete listing of mitigation measures can be found in Chapter Nine. Chapter Seven also provides information on requirements for solid waste and wastewater disposal in the Sale Area.
E. Reasonably Foreseeable Cumulative Effects on Terrestrial Habitats and Wildlife

Potential oil and gas activities that could have cumulative effects on terrestrial habitats and wildlife within the Sale Area include seismic surveys, construction of production and support facilities, drilling and production activities, discharges from well drilling and production, transportation, and gas blowouts or oil spills. Some potential cumulative effects of these activities include physical changes and disturbance that could alter the landscape, waterbodies, and wetlands; habitat availability and suitability; and behavior of wildlife (NRC 2003).

Indirect cumulative effects of oil and gas exploration and production can include artificial increases in numbers of predators such as gulls, ravens, raptors, bears, or foxes from access to garbage, cover, and perching habitats associated with camps and infrastructure, which may depress nesting success of ground-nesting birds in the surrounding area (Liebezeit et al. 2009; Wallace et al. 2016; Meixell and Flint 2017).

1. Potential Cumulative Effects on Terrestrial Habitats and Wildlife

Cumulative effects of oil and gas activities on terrestrial habitats and wildlife are primarily related to habitat loss from construction of roads, pads, and facilities and habitat alteration from indirect effects resulting from construction and use of these facilities such as altered drainage patterns, fugitive dust, and changes in vegetation cover that lead to increased areas of thermokarst. Activity, vehicle traffic, aircraft traffic, sounds from equipment and machinery, and changes in vegetation types can result in reduced use or avoidance of the area surrounding oil and gas facilities by some wildlife especially during sensitive calving, denning, over winter, nesting, and migration periods (Liebezeit et al. 2009; Meixell and Flint 2017; Johnson, H. E. et al. 2019; Prichard et al. 2020). The Sale Area contains primarily upland habitats with rolling hills covered by tussock low-shrub/tussock tundra with willow thickets along rivers and Dryas tundra on ridges between the National Petroleum Reserve – Alaska (NPR-A) and the Arctic National Wildlife Refuge (ANWR; see Table 4.1).

Attributing potential cumulative effects from normal oil and gas activities to population level changes is often problematic as it is not usually possible to distinguish oil and gas activity effects independently from other potential sources of population variation including: weather events, precipitation, and snow depth; flood, fire, vegetation succession, pest, and disease induced changes in habitat quality; disease outbreaks; immigration and emigration; and predation and hunting mortality (Wasser et al. 2011; Brockman et al. 2017; Plante et al. 2020).

a. Seismic Surveys

Oil and gas activities in the Sale Area require off road travel across the tundra in winter for seismic exploration activity, ice road construction for exploratory drilling, and routine maintenance of infrastructure such as pipelines. Modern exploration techniques and equipment coupled with limitations on the timing of tundra travel have mitigated the most severe impacts on vegetation and permafrost characteristics (DNR 2015). However, evidence of past practices such as travel on unfrozen ground, travel across frozen ground with inadequate snow cover, or removal of vegetation during seismic surveys and associated camp moves remain visible on the landscape for decades (Jorgenson et al. 2010; Walker et al. 2019). Although current practices specify minimum snow depths and ground hardness before tundra travel is allowed, impacts to vegetation and underlying permafrost may still occur (Kemper and Macdonald 2009; Walker et al. 2019; Raynolds et al. 2020). Estimates from two seismic programs in the 1990s found that 6 percent of seismic lines and...
29 percent of camp move trails sustained medium to high initial disturbance; while 4 percent of seismic lines and 63 percent of camp move trains remained disturbed after 6 years (Jorgenson et al. 2010). The footprint created by seismic exploration, especially three-dimensional seismic exploration, over the last decades covers a larger geographic area than all other direct human impacts combined (NRC 2003; Jorgenson et al. 2010; Walker et al. 2019). Long-term studies document that after 33 years, 3 percent of seismic trails and 5 percent of camp move trails may continue to show measurable changes to vegetation communities (Raynolds et al. 2020).

Winter seismic surveys can affect tundra vegetation through reduced vegetation cover and diversity and increased active layer depth, based on snow depth, vehicle type, traffic pattern, and vegetation type (Kemper and Macdonald 2009; Jorgenson et al. 2010; Walker et al. 2019; Raynolds et al. 2020). Damage has been observed to shrubs, forbs, lichens, and tussocks within North Slope oilfields, with more significant impacts observed on higher, drier sites, with little to no evidence of damage observed in wetter habitats (NRC 2003). Vehicles would likely leave visible packed snow tracks in the tundra the following spring, and visible tracks may persist into the summer (Walker et al. 2019; Raynolds et al. 2020). In most instances, vegetation within tracks should recover over the span of several years where disturbance levels are low to moderate, especially in wet tundra habitats (Kemper and Macdonald 2009; Jorgenson et al. 2010). Most seismic trails would recover within 8 to 10 years, although up to 10 percent of moderate to highly disturbed areas may remain disturbed after several decades (Jorgenson et al. 2010; Walker et al. 2019). Long-term changes in plant communities include increased cover of graminoid plants and decreased cover of evergreen shrubs and mosses (Jorgenson et al. 2010). Where vegetation damage leads to an increase in active layer depth, impacts are similar to impacts observed from winter seismic conducted from about 30 years ago (Kemper and Macdonald 2009), with camp move vehicles causing most of the damage that is likely to persist (Jorgenson et al. 2010; Walker et al. 2019).

Some seismic trails on ice-rich, fine-grained soils may remain altered after 25 years because changes in hydrology caused by increased thaw depths and ground subsidence have led to shifts in vegetation composition toward wetter tundra plant communities (Walker et al. 2019; Raynolds et al. 2020). These trails may not recover to pre-disturbance conditions. Tussocks, which can be up to 10 inches tall, are susceptible to scraping, compaction, and breakage. Later freeze-up in fall and earlier snowmelt in spring have shortened the ice-road and tundra-travel season on the North Slope (Raynolds et al. 2020). Snow cover is fairly uniform across the Sale Area with an average end of winter snow depth of 17.4 inches in the Upper Kuparuk and Innvaivat drainages (Stuefer, Kane and Dean 2019; Stuefer, Kane, Gieck, et al. 2019). DNR requires at least 9 inches snow cover before winter tundra travel is allowed to protect tussock tundra (Raynolds et al. 2020). Habitats most susceptible to long-term damage from seismic exploration in the Sale Area shown in Figure 8.5 include areas with high ground ice (high thermokarst predisposition, 13 percent) and areas with tussock/tussock-shrub tundra or Dryas tundra (57 percent; Jorgenson et al. 2010).

Caribou, muskoxen, moose, Dall sheep, brown bears, and foxes likely remain within or near the Sale Area in winter. Known winter use areas for moose, muskoxen, and Dall sheep are shown in Figure 8.6. An estimated 52 percent of the Sale Area contains high quality caribou winter foraging habitat (Trammell et al. 2015). The Sale Area covers an estimated 19 percent of the Central Arctic Herd (CAH) winter range, 14 percent of the Teshekpuk Caribou Herd (TCH) winter range, and 14 percent of winter moose range in the arctic region. As the CAH increased from 4,000 to 6,000 caribou in the 1970s to more than 32,000 caribou in the mid-2000s the herd’s use of winter range changed from primarily north of the Brooks Range in the 1970s to 54 to 69 percent of the herd wintering south of the Brooks Range during 2003 to 2006 (Nicholson et al. 2016). On average more than half (66 percent) of the CAH radio collared cows were located on the south side of the Brooks Range during March/April 2002 to 2020, with a range of 2 to 100 percent (Lenart 2015). Dall sheep
winter range in the Sale Area is limited to the Galbraith and Atigun Pass area, which has been
selected by the state but is currently owned and managed by the Bureau of Land Management
(Figure 8.6).

Seismic exploration vehicles compact snow and underlying vegetation reducing forage availability
during winter. Disturbance from human activity and noise in winter, such as those generated by
seismic exploration usually displace ungulates (Harris et al. 2014). Winter disturbances are likely
most detrimental to northern ungulates (caribou, moose, muskoxen, Dall sheep) when they are
unpredictable, cover large areas, last for extended periods, and when animals are displaced from
high quality habitats (Harris et al. 2014; Plante et al. 2020).

No recent studies specific to the effects of disturbance from winter seismic exploration on terrestrial
wildlife were identified. Most studies cited for seismic exploration disturbance effects on wildlife
are observational, gray literature, and were completed more than 30 years ago (Russell 1977;
Garner and Reynolds 1986). Caribou and muskoxen are likely to be temporarily displaced by
seismic exploration although the consequences of exposure to this disturbance are unlikely to be
serious for caribou (Plante et al. 2020). Caribou moved away from seismic survey activity
occurring within 1/2 mile but not within 3/4 mile, and returned to use habitats near the seismic lines
within 2 to 4 days (Russell 1977). Muskoxen moved away from seismic exploration activities
within 3/4 to 4 miles returning in a week in one study, while another found no long-term or
widespread changes in distribution or use of traditional areas (Russell 1977; Garner and Reynolds
1986). Moose are also expected to be displaced temporarily by winter seismic exploration activities
(Harris et al. 2014). Moose depend on riparian habitats for forage in the Sale Area and long-term
displacement from these habitats could reduce survival. Moose react to recreational snowmachine
traffic by displacement by 33 feet to 0.4 mile, with disturbance reactions lasting 6 minutes in
southeastern Alaska (Harris et al. 2014). Dall sheep are not expected to be exposed to disturbance
from seismic surveys, since little winter Dall sheep habitat occurs in the Sale Area (Figure 8.6).
Figure 8.5.—Permafrost and vegetation communities susceptible to seismic survey damage.

Source: (Jorgenson et al. 2010; Trammell et al. 2015; Boggs et al. 2019)
Figure 8.6.—Winter moose, muskoxen, and Dall sheep habitat in the Sale Area.

Source: (ADF&G 1986)
Brown bears may den along river bluffs, ridges, or pingoes within the Sale Area. Activity near bear den sites could disturb hibernating bears such that they prematurely emerge from the den (Linnell et al. 2000). If there are cubs, and the sow abandons the den, cubs would likely perish. Winter activities are required to avoid known bear dens. While dens sites cannot be predicted, many brown bears that frequent North Slope oil fields are equipped with radio-collars and can be located while in dens. Other methods used to detect bear dens so that they may be avoided include Forward Looking Infrared (FLIR) surveys and scent-trained service dogs (Shideler 2015). Foxes remain active during winter and may be displaced from dens by nearby seismic activities, although foxes may also be attracted to remote camps, which could facilitate the spread of rabies (Hueffer and Murphy 2018). Fox winter survival may be enhanced by access to cover and warmth at remote seismic camps, or by access to garbage that provides supplemental nutrition (NRC 2003). Potential disturbances to terrestrial mammals from winter seismic surveys would be a temporary impact and although caribou, moose, muskoxen, Dall sheep, brown bears, and foxes wintering within the Sale Area may be temporarily displaced, impacts are not likely to be cumulative or substantially affect healthy wildlife populations.

Closely spaced three-dimensional seismic surveys can lead to extensive areas of packed snow with delayed melt and altered micro-topography that can alter active-layer and permafrost conditions leading to both short-term (following spring) and potentially longer-term changes in vegetation (Walker et al. 2019). These changes may reduce habitat availability and suitability for ground-nesting passerines, shorebirds, and ptarmigan primarily through compression of standing dead vegetation used to construct and conceal nests or longer term through changes in microtopography and site wetness.

b. Exploration, Development, and Production

Exploration, development, and production generally require construction and continued use of support facilities including ice or gravel roads, production pads, airstrips, gathering and transport pipelines, processing facilities, and living quarters for field personnel. North Slope production facilities generally require a gravel fill pad and access roads. Potential cumulative effects are primarily related to habitat loss that include direct loss through cover by facilities and functional losses through habitat alteration and behavioral displacement or intentional hazing of wildlife away from facilities. Oil and gas development may also directly affect wildlife through collision mortality (Child 2007; Northrup and Wittemyer 2013). Habitat alteration from indirect effects from construction and use of these facilities includes altered drainage patterns, fugitive dust, accelerated thermokarst, and related changes in vegetation cover (NRC 2003; Raynolds et al. 2014). Thermokarst has affected broad areas within the Prudhoe Bay oilfield with a sudden increase in the area affected beginning after 1990 coincident with a rapid rise in regional summer air temperatures and related permafrost temperatures. Road dust and roadside flooding contribute to thermokarst in areas next to roads and gravel pads. Infrastructure development for North Slope oilfields from 1968 to 2011 show that by 2010, over 34 percent of the intensively mapped area within the Prudhoe Bay oilfield was affected by oil development (Raynolds et al. 2014). Between 1990 and 2001, 19 percent of the remaining natural landscapes showed expansion of thermokarst features resulting in more abundant small ponds, increased microrelief, lakeshore erosion, and landscape and habitat heterogeneity (Raynolds et al. 2014).

Activity, vehicle traffic, aircraft traffic, sounds from equipment and machinery, and changes in vegetation types can result in reduced use or avoidance of the area surrounding oil and gas facilities by caribou (NRC 2003; Vistnes and Nellermann 2006; Johnson, H. E. et al. 2019). Caribou response to North Slope oil and gas development have been the focus of decades of research that has generally concluded: the intensively developed Prudhoe Bay oilfield has altered the distribution of female caribou during the insect season; calving concentrations west of the Sagavanirktok River
have shifted inland away from developed areas to lower quality habitats; and exposure of cows to oilfield infrastructure reduces their productivity because infrastructure impairs movements between coastal insect-relief habitats and inland foraging habitats (NRC 2003). While there is substantial evidence that parturient cows likely avoid areas close to roads and pads with traffic, the avoidance distance, duration, and consequences are equivocal as cow caribou appear to approach closer and cross infrastructure later during the calving and post-calving periods (Haskell et al. 2006; Nicholson et al. 2016; Johnson, H. E. et al. 2019; Prichard et al. 2020). There is some evidence that caribou avoidance response to disturbance may lessen after continuous exposure over decades (Johnson, C. J. and Russell 2014), but habituation is also equivocal (Johnson, H. E. et al. 2019). A comprehensive review of published research on disturbance effects on caribou and reindeer, however, concluded that study design limitations and publication bias have influenced our current knowledge of effects of human disturbance on caribou and reindeer (Flydal et al. 2019). Most studies did not include before–after designs (76 percent), did not include spatiotemporal variation (64 percent), and did not consider long enough time intervals (15 percent with more than 10 years of data) to characterize spatial fluctuations in habitat use (Flydal et al. 2019). This review found that for analyses from 52 studies 64 percent of the authors focused their conclusions on negative effects, although only 53 percent of the outcomes actually documented negative effects, 34 percent showed no effects and 13 percent showed positive effects of human activities and infrastructure on caribou or reindeer (Flydal et al. 2019). Even when positive effects were presented, Flydal et al. (2019) found a bias towards focusing discussions and conclusions towards negative effects and in most cases positive effects were either ignored or addressed critically.

Caribou from the CAH, TCH, and Western Arctic herd (WAH) use habitats in the Sale Area during late-summer, spring and fall migration, fall and winter (Figure 8.7 to Figure 8.10). Calving generally occurs well north of the Sale Area. The most likely cumulative effects associated with oil and gas development in the Sale Area are roads and pipelines that may alter caribou use of late-summer and winter foraging habitats and spring and fall migration corridors between calving and winter habitats. Use of elevated pipelines and separation of roads and pipelines are designed to minimize potential cumulative effects on caribou movements (Cronin et al. 1994). Roads and pipelines to access and transport oil from the Sale Area have a potential to alter spring and fall movements of caribou especially where migration paths show high concentration where they cross the Dalton Highway and TAPS between the Ribdon and Kuparuk rivers (Nicholson et al. 2016). Roads across migratory pathways may delay caribou migration and use of migratory corridors may decline with increased development (Wilson et al. 2016; Sawyer et al. 2020). Caribou continue to use habitats within the North Slope oilfields in summer (Arthur and Del Vecchio 2009; Nicholson et al. 2016; Johnson, H. E. et al. 2019; Prichard et al. 2020) and with implementation of mitigation to allow for unimpeded movement, cumulative effects on caribou are expected to be moderate to minor.
Figure 8.7.—Caribou late-summer distribution in the Sale Area.
Figure 8.8.—Caribou spring migration distribution in the Sale Area.

Source: (ABR 2019)
Figure 8.9.—Caribou fall migration distribution in the Sale Area.

Source: (ABR 2019)
Figure 8.10.—Caribou winter distribution in the Sale Area.

Source: (ABR 2019)
Arctic caribou populations undergo cyclic or near cyclic fluctuations in the range of 40 to 90 years and while the mechanisms driving fluctuations are unknown, they are possibly related to large-scale climatic oscillations (Arctic Oscillation [AO], Pacific Decadal Oscillation [PDO]), density-dependent interactions with forage plants, or interactions with predators (Fauchald et al. 2017). Annual sea ice cover explains much of the climate-induced greening on caribou summer ranges, measured as the June-to-August normalized difference vegetation index (NDVI), and consequently on caribou population dynamics (Fauchald et al. 2017); although NDVI alone may be poorly related to forage quality in northern Alaska (Johnson, H. E. et al. 2018). Sea ice loss promotes local warming over the adjacent land increasing primary production or greening of summer ranges which may result in poor range quality (Fauchald et al. 2017). Increases in summer primary productivity have also been shown or predicted to positively affect caribou and reindeer body condition, fecundity, and population growth (Trammell et al. 2015; Mallory and Boyce 2018). Cumulative effects from normal oil and gas activities and development on caribou population dynamics may be additive (NRC 2003), but masked by and indistinguishable from interactions between large-scale climate patterns (AO and PDO) or global climate change with weather-related habitat and forage changes that affect caribou population dynamics (Joly and Klein 2011; Joly et al. 2011; Fauchald et al. 2017).

Brown bear dens along river or coastal bluffs within the Sale Area, may be disturbed by winter construction of ice roads, gravel pads and roads, pipelines, and gravel extraction. Equipment and construction noise and explosions from gravel extraction near bear den sites could disturb hibernating bears such that they prematurely emerge from the den (Linnell et al. 2000). Winter exploration and development activities are required to avoid identified bear dens. Cumulative effects on brown bears from North Slope oil and gas development have resulted in changes in population demographics due to the availability of supplemental food from garbage, which increases productivity, and results in increases in defense of life and property kills for food conditioned bears (Shideler and Hechtel 2000; NRC 2003). Pre-construction den surveys, improved food waste containment and management, and human-bear interaction plans are required mitigation to avoid and minimize potential oil and gas related impacts on brown bears.

Birds use terrestrial and freshwater habitats within the Sale Area for nesting, brood-rearing, and foraging. Cumulative effects from oil and gas development related to birds are primarily related to direct habitat loss and alteration. While previous cumulative effects analyses identified changes in nesting distribution and increased predation leading to decreased productivity within North Slope oilfields (NRC 2003), more recent studies and landscape-scale evaluations conclude that disturbance related effects do not appear to have altered overall nest density or significantly reduced nest survival (Liebezeit et al. 2009; Bart et al. 2013; Bentzen et al. 2017; Meixell and Flint 2017; Pearce et al. 2018). While it has long been held that fox density and den occupancy rates are artificially high within the Prudhoe Bay region because of the availability of artificial shelter and food (Burgess 2000; NRC 2003; Stickney et al. 2014), surveys encompassing the entire coastal plain from 1992 to 2010 indicate that fox densities are similar within the Prudhoe Bay oilfield compared to the surrounding area and foxes are more numerous where aquatic birds are more numerous in the northern part of the NPR-A (Bart et al. 2013).

Animals use sound for communication, navigation, avoiding danger, and finding food. Increased background noise can interfere with animals receiving these important signals. Animals have been found to compensate for a noisy environment by changing the frequency, rate, and timing of vocal signals (FHWA 2004). Noise from oil and gas activities can have variable effects on wildlife such as: changes in temporal patterns, changes in distribution and movement, decreases in foraging, increases in vigilance and antipredator behavior, changes in mating behavior and territorial defense, and temporary or permanent hearing loss (FHWA 2004; Kight and Swaddle 2011; Francis and
Barber 2013). Chronic and frequent noise such as operating compressors can interfere with an animal’s ability to detect important sounds, while periodic, unpredictable loud noises can be interpreted as threatening (Francis and Barber 2013). If noise becomes a constant stressor, it can reduce reproductive success and long-term survival (FHWA 2004). Cumulative effects of noise generated during oil and gas activities on wildlife are likely to lead to localized short-term disturbance and displacement effects during exploration and development, and localized long-term displacement effects during production for sensitive animals during sensitive periods such as nesting, denning, and near parturition. Oil and gas activities may be limited during sensitive periods within important habitats to minimize disturbance; permanent facilities are generally sited away from sensitive habitats and are designed to reduce noise exposure to the surrounding environment. With implementation of best management practices and mitigation that minimizes noise disturbance, cumulative effects on wildlife are expected to be moderate to minor.

c. Discharges, Leaks, and Spills

Discharges from well drilling and production may be intentional, such as permitted discharges regulated under APDES or National Pollutant Discharge Elimination System (NPDES) permits, or unintentional, such as gas blowouts, leakages, and spills. Excluding oil spills, activities related to oil and gas exploration, development, and production are considered to be minor contributors of petroleum hydrocarbons to the environment (Huntington 2007).

Potential effects of oil spills on terrestrial habitats depend on the size of the spill, type of oil spilled, time of year, type of vegetation, and terrain. Spilled oil spreads both horizontally and vertically depending on the volume spilled, type of ground cover (plant or snow), slope, presence of cracks or troughs in the ground, moisture content of the 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). Oil spreads less when it is thicker, cooler, or is exposed to chemical weathering. If the ground temperature is below the pour point of the oil (the temperature where oil will pour or flow), oil pools and is easier to contain. Because dry soils are more porous, the potential for spilled oil to seep downward into the soil is greater (Everett 1978). If oil penetrates the soil layers and remains in the plant root zone, longer-term effects, such as mortality or reduced regeneration could occur in following summers. Under the right conditions involving oxygen, temperature, moisture in the soil, and the composition of the spilled oil, bacteria may assist in the breakdown of hydrocarbons in soils.

Cumulative effects of discharges, leaks, and spills on terrestrial wildlife are related primarily to exclusion from and temporal loss of contaminated habitats, although some individual animals may be lost from toxic effects. Oil spills may result in habitat degradation, changes in prey or forage availability, and contamination of prey or forage resources. Changes in preferred prey or forage may lead to displacement into lower quality habitats with reduced prey or forage, which can reduce survival or reproductive fitness. Sublethal physiological and ecological effects of oil may persist after cleanup activities have concluded and may have consequences on the fitness of individuals and populations (Henkel et al. 2012; Burns et al. 2014).

Toxicity from direct contact with oil, inhalation of fumes, and ingestion through cleaning, preening, or consuming contaminated prey can result in the loss of exposed individuals. Crude oil coating fur or feathers leads to reduced buoyancy, hypothermia (low body temperature), hyperthermia (high body temperature), and toxin absorption. Ingestion of crude oil through grooming or preening can lead to hemolytic anemia (destruction of red blood cells), kidney and liver damage, and central nervous system damage (EPA 1999). Chronic exposure to polycyclic aromatic hydrocarbons that occur within fuels, lubricants, and crude oil can lead to immunosuppression and genetic mutation (Burns et al. 2014).
Mammals can be affected by breathing vapors or ingesting oil, which can cause lung, digestive tract, and liver and kidney damage (EPA 1999). Carcasses can attract predators such as bears and foxes to spill sites. Small mammals can inhale hydrocarbon vapors near the ground surface which can lead to lung and nerve damage and behavioral abnormalities (EPA 1999). Ingested toxins can be transferred through the blood to offspring through the placenta or milk (Burns et al. 2014). Birds can ingest oil during preening or feeding on contaminated prey, which can lead to weight loss, hemolytic anemia, kidney damage, liver damage, foot problems, gut damage, and immunosuppression (Troisi et al. 2006). Eagles and other raptors may become contaminated by feeding on oiled carcasses, and shorebirds are vulnerable to spills that reach water because they spend much of their time foraging in shoreline habitat (Henkel et al. 2012). Nesting birds that get oil on their legs and chest can transfer oil to eggs during incubation, which can suffocate the egg or lead to developmental abnormalities and reduced survival (Burns et al. 2014).

Spill response and cleanup activities may disturb and displace wildlife although effects are likely to be short-term not cumulative. In situ burning to remove spilled oil could injure or kill a few small mammals. Cleanup operations decrease the likelihood that wildlife will contact oil or oiled forage or prey. Because of the potential for oil spills to impact fish and wildlife resources, spill and leak prevention are a focus of oil and gas industry regulation and spill response planning requirements as discussed in detail in Chapter Six.

2. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on terrestrial habitats and wildlife populations, although cumulative impacts are expected to be localized and minor. Cumulative effects are most likely to include some direct habitat loss and alteration from facilities and disturbance from vehicle and air traffic, construction, drilling, and production sounds.

Oil and gas development and production are most likely to contribute to cumulative effects on terrestrial habitats and wildlife through construction and use of permanent roads, airstrips, facilities, and the associated activity. Because most terrestrial habitats within the Sale Area are tussock tundra and mesic tundra, cumulative effects to terrestrial habitats from seismic surveys are expected to be minor to moderate although most tussock and mesic tundra habitats would be expected to recover within 8 to 10 years. The greatest potential for cumulative effects in the Sale Area is blockage or alteration of caribou movements during migration. Mitigation for pipeline height and separation of roads and pipelines are designed to allow for free passage of caribou. Pre-construction den surveys, improved food waste containment and management, and human-bear interaction plans are required mitigation to avoid and minimize oil and gas impacts on brown bears. Oil and gas activities may be limited during sensitive periods within important habitats to minimize disturbance; permanent facilities are generally sited away from sensitive habitats and are designed to reduce noise exposure to the surrounding environment. With implementation of best management practices and mitigation that minimizes disturbance, cumulative effects on wildlife are expected to be moderate to minor. In addition, all migratory birds are protected under the Migratory Bird Treaty Act, and eagles are additionally protected under the Bald and Golden Eagle Protection Act.

Specific wildlife mitigation measures included in this best interest finding address avoidance of habitat loss; protection of wetland, riparian, and aquatic habitats; disturbance avoidance; and free passage and movement of wildlife. Mitigation measures protect denning brown bears and prevent bears from becoming food conditioned or unnecessarily destroyed during interactions with workers. Other measures and regulatory protections address seismic exploration activities, facility siting, pipelines, drilling waste, oil spill prevention and control, and rehabilitation.
A complete listing of mitigation measures can be found in Chapter Nine. Chapter Seven also provides information on requirements for solid waste and wastewater disposal in the Sale Area.

**F. Reasonably Foreseeable Cumulative Effects on Fish and Wildlife Uses**

As described in Chapter Five, fish and wildlife resources in the Sale Area support local subsistence, sport fishing, and hunting, as well as non-consumptive recreation and tourism use. Consumptive and non-consumptive uses both depend on healthy habitats and wildlife populations, which can experience cumulative effects from oil and gas activities as described above. Additional potential effects on consumptive uses are discussed in the following sections.

Potential post-disposal activities that could have cumulative effects on fish and wildlife uses within the Sale Area include seismic surveys, construction of support facilities, discharges from well drilling and production, and ongoing disturbances from development and production activities such as vehicle and aircraft traffic. In addition, gas blowouts and oil spills could potentially occur during exploration, development, and production.

1. **Potential Cumulative Effects on Subsistence**

Subsistence activities and foods anchor cultural wellbeing and nutritional health in the North Slope Borough (NSB), and security of food resources is a key issue of public concern (NSB 2012). Subsistence uses depend on healthy fish and wildlife populations and habitats. Post-disposal oil and gas activities could potentially have cumulative effects on subsistence activities of local residents near the Sale Area by affecting the availability of fish and wildlife populations, by disruption or displacement of subsistence activities, or by contamination of subsistence resources (SRBA 2009, 2010, 2017; Brown et al. 2016). Developing effective mitigation measures to protect fish, wildlife, habitats, and subsistence continues to be a focus of management agencies and industry. High use subsistence areas within the Sale Area (Figure 8.11) occur along the Colville, Chandler, and Anaktuvuk rivers (SRBA 2010, 2013; Harcharek 2015).

Arctic coastal communities characterized oil and gas impacts to subsistence activities during 2016, with 64 percent of Nuiqsut respondents and 24 percent of Utqiagvik respondents reporting that subsistence activities were impacted by oil development. The inland subsistence activity most impacted by oil development was caribou hunting disruption from aircraft (SRBA 2017). Anaktuvuk Pass concerns were that nonlocal and nonresident hunters and air traffic diverting caribou and moose from migration routes and competition from nonlocal and nonresident hunters for caribou, moose, and Dall sheep resources (Brown et al. 2016). Nuiqsut respondents, the community closest to oil and gas development, are more likely than Utqiagvik respondents to report pollution from industrial development in 2016, that fish or animals may be unsafe to eat, and that they avoid eating certain subsistence foods because of contamination. While Nuiqsut was more likely to report negative impacts of oil and gas development on subsistence, these impacts did not reach levels that affected satisfaction with the amount of fish and game available locally or with opportunities to fish and hunt (80 percent satisfied; SRBA 2017).
Source: (SRBA 2010, 2013)

Figure 8.11.—High use subsistence areas in the Sale Area.
While most households reported having enough food in 2016, foods available were not always preferred (Table 8.6). During 2014, most households in Utqiaġvik (91 percent), Nuiqsut (90 percent), and Anaktuvuk Pass (81 percent) reported high and marginal food security. Nearly a quarter of households in these communities, however, reported a lack of resources (time, money, or equipment) to get food (Brown et al. 2016).

Table 8.6.—Household descriptions of foods eaten in last 12 months, 2014.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Utqiaġvik</th>
<th>Nuiqsut</th>
<th>Anaktuvuk Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Had enough of the kinds of foods desired</td>
<td>52.9%</td>
<td>46.6%</td>
<td>39.6%</td>
</tr>
<tr>
<td>Had enough food, but not desired kind</td>
<td>37.5%</td>
<td>41.4%</td>
<td>41.5%</td>
</tr>
<tr>
<td>Sometime, or often, did not have enough food</td>
<td>5.4%</td>
<td>6.9%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Missing/No response</td>
<td>5.0%</td>
<td>5.2%</td>
<td>13.2%</td>
</tr>
</tbody>
</table>

Source: (Brown et al. 2016)

Interview surveys for households in Utqiaġvik, Kaktovik, Nuiqsut, Wainwright, Point Lay, and Point Hope span from 1977 to 2016 correspond with onshore and nearshore oil and gas development on the North Slope. Survey responses indicate that participation in subsistence activities has increased over this period from a mean of three subsistence activities in 1977 and 1988 to a mean of five subsistence activities in 2003 and 2016. The number of months with 5 or more days of subsistence activities has remained relatively stable over this period from a mean of 4 months in 1977 to a mean of 3 months in 2016. The proportion of subsistence meat and fish consumed by households also remained relatively stable from 2003 and 2016. While the proportion of households using subsistence for more than half of their meat and fish was reduced from 64 percent in 2003 to 47 percent in 2016, the percentages of households harvesting more than half of their meat and fish was not different from 2003 to 2016. Households were less satisfied with the amount of fish and game available locally in 1977 than in either 2003 or 2016; likely due to restrictions implemented on hunting of the Western Arctic caribou herd in 1977. Satisfaction with the amount of fish and game available locally from 2003 and 2016 remained consistent. In addition, perceptions of pollution from industrial development in the region as an environmental problem remained consistent from 2003 to 2016; while consideration of climate change as an environmental concern increased from 70 percent in 2003 to 85 percent in 2016 (SRBA 2017).

a. Caribou

While Nuiqsut hunters use oilfield roads for hunting, access by caribou hunters to oilfield complexes has been reduced because hunting is prohibited within some, but not all, oilfield areas. The primary oil and gas activity disrupting caribou harvest activities reported during household surveys is air traffic (Table 8.7). Low pipelines and high road berms are physical barriers to all-terrain vehicles and snowmachines, with many hunters reluctant to enter oilfields for personal or aesthetic reasons (NRC 2003). Hunters report that caribou are displaced by pipelines, aircraft overflights, seismic testing, noise from development operations and traffic (SRBA 2009). Although multiple summer studies concluded that caribou cross under pipelines elevated 5 feet above the tundra (Cronin et al. 1994), hunters noted that pipelines elevated to less than 7 feet appear to interrupt caribou migration, especially when snow builds up under the pipeline (SRBA 2009). Newer pipelines are elevated to 7 feet as prescribed in lease mitigation measures.
Caribou hunters in Anaktuvuk Pass are concerned with declining caribou numbers and changing migration patterns caused by nonlocal hunters, that some believe were illegally using planes in the Anaktuvuk Pass Controlled Use Area (Brown et al. 2016). They also believed that roads and natural resource development in the area could have irreversible negative impacts on their subsistence way of life (Brown et al. 2016).

Table 8.7.—Number of responses identifying oil and gas impacts to caribou harvest activities in 2016.

<table>
<thead>
<tr>
<th>Impact or Activity</th>
<th>Utqiagvik</th>
<th>Nuiqsut</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of impact on caribou harvest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditory disruption</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>Displacement of wildlife</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>Difficulty hunting</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Disruption of wildlife</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Need to travel farther</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ability to hunt</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Movement impediments</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><strong>Industry activity affecting caribou harvest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helicopters/small planes/drones</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>Drilling</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Bridges/roads/ice roads/causeways</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Industry vessels/barges</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Seismic testing</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Exploration</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Oil spills/cleanup</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Infrastructure/facilities/vehicles</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Industry development – all aspects</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ship activity</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: (SRBA 2017)
Note: Similar survey data were not available for Anaktuvuk Pass hunters.

b. Oil Spills and Contamination

In 2016, oil spill and cleanup activities were identified as impacting caribou hunting by one Nuiqsut survey respondent (Table 8.7). Of the 12 environmental issues identified by survey respondents, Nuiqsut was more likely to report that fish or animals may be unsafe to eat than Utqiagvik (Table 8.8). Although local pollution and contamination also includes military sites, Nuiqsut respondents were more likely to report pollution from industrial developments as an issue compared to Utqiagvik; and about half of Nuiqsut respondents reported avoiding subsistence foods in 2016 because of perceived contamination (Table 8.8).

Persistent organic pollutants (POPs), their precursors, degradation products and metabolites are carried into the Arctic from lower latitudes through long-range atmospheric transport, ocean currents, and rivers (AMAP 2018); major contaminant transport pathways, however, lead elsewhere in the Arctic and have had little influence on the North Slope (NSB 2006). POPs and methylmercury bioaccumulate and biomagnify through the marine food web and are a concern for
fish and wildlife and indigenous subsistence consumers (AMAP 2018). During the past two decades, concentrations of many of these pollutants have decreased after nations agreed to reduce or eliminate their production, use, and release in the 1970s (AMAP 2018). Polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and hexachlorobenzene concentrations in bowhead whale tissues ranged from 2 to 5 times lower in 2015 compared to 1992 (NSB 2019b). Polybrominated diphenylethers (PBDEs used as a flame retardant), POPs, and polycyclic aromatic hydrocarbons (PAHs) remain detectable, but at low concentration in a few polar bears (NSB 2019b). Concerns with PCB and DDT contamination in Colville River fish arose from point source contamination identified from a military landfill near Umiat. Samples from arctic grayling and burbot in August 2015 near the site found that contaminant concentrations appear to have decreased from sampling in 1998 and 2001 and do not pose a significant health risk (TPECI and Fisheye 2015).

Table 8.8.—Environmental issues for Sale Area communities in 2016.

<table>
<thead>
<tr>
<th>Environmental Problems</th>
<th>Utqiagvik</th>
<th>Nuiqsut</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>84%</td>
<td>89%</td>
</tr>
<tr>
<td>Erosion of coastal areas or riverbanks</td>
<td>80%</td>
<td>85%</td>
</tr>
<tr>
<td>Fish or animals that may be unsafe to eat</td>
<td>46%</td>
<td>64%</td>
</tr>
<tr>
<td>Local contaminated sites</td>
<td>44%</td>
<td>40%</td>
</tr>
<tr>
<td>Disposal of hazardous waste</td>
<td>45%</td>
<td>25%</td>
</tr>
<tr>
<td>Pollution from industrial development</td>
<td>40%</td>
<td>65%</td>
</tr>
<tr>
<td>Pollution of local lakes and streams</td>
<td>40%</td>
<td>43%</td>
</tr>
<tr>
<td>Pollution of offshore waters</td>
<td>37%</td>
<td>35%</td>
</tr>
<tr>
<td>Disposal of sewage</td>
<td>34%</td>
<td>35%</td>
</tr>
<tr>
<td>Pollution from other countries</td>
<td>35%</td>
<td>11%</td>
</tr>
<tr>
<td>Pollution from landfills</td>
<td>28%</td>
<td>46%</td>
</tr>
<tr>
<td>Disruption of views and landscapes</td>
<td>28%</td>
<td>29%</td>
</tr>
<tr>
<td><strong>Subsistence Foods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid eating due to perceived contamination</td>
<td>26%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Source: (SRBA 2017)
Note: Similar survey data were not available for Anaktuvuk Pass.

2. Potential Cumulative Effects on Hunting and Sport Fishing

The primary cumulative effect from oil and gas development is related to changes in public access from construction of new roads and trails (NSB 2014). During oil and gas development and production, the public use of oil field roads may be prohibited, excluding public access to public lands with potentially cumulative effects on hunting and fishing access (USFWS 2016). After oil and gas production ceases and fields are decommissioning, the land management agency may elect to retain access roads and pads which may be repurposed to enhance access (NSB 2014). Increased public access to hunting, trapping, and fishing areas through construction of new roads and trails or opening roads to the public could increase harvest efficiency although roads and infrastructure may be considered aesthetically displeasing. New roads and trails could also increase competition.
between local North Slope resident and nonlocal Alaska resident and nonresident users for fish and wildlife resources (NSB 2014).

3. Mitigation Measures and Other Regulatory Protections

Oil and gas activities could potentially have cumulative effects on subsistence activities, sport fishing, and hunting primarily through cumulative effects of disruption and displacement of fish and wildlife resources or harvesters, changes in access, and competition among user groups. Mitigation measures specifically address Dolly Varden overwintering and/or spawning areas, brown bears, waterbirds, Dall sheep lambing areas and mineral licks, and caribou or other large ungulate calving and wintering areas. Mitigation measures address disturbance avoidance, particularly for fall caribou migration; seismic activities; siting of facilities; pipelines; oil spill prevention and control; and discharges and waste from drilling and production. In addition to mitigation measures addressing fish, wildlife, and habitat, other mitigation measures specifically address harvest interference avoidance, public access, road construction, and oil spill prevention.

Specific harvest interference mitigation requires:

- consultation with potentially affected local subsistence users, communities and the North Slope Borough;
- no permanent facilities, except for roads or pipelines within the Chandler, Anaktuvuk, Nanushuk, Itkillik, and Kuparuk river valleys;
- potential seasonal restrictions on exploration activities and exploratory drilling during fall caribou migration in the Chandler, Anaktuvuk, Nanushuk, Itkillik, and Kuparuk river valleys to allow for subsistence hunting; and
- potential lease-related use restrictions to prevent unreasonable conflicts with local subsistence, sport fish, or nonlocal and nonresident wildlife harvest activities.

Measures in this best interest finding, along with regulations imposed by state, federal and local agencies, are expected to avoid, minimize, and mitigate potential cumulative effects on fish and wildlife uses. A complete listing of mitigation measures is found in Chapter Nine.

G. Reasonably Foreseeable Cumulative Effects on Historic and Cultural Resources

1. Potential Cumulative Effects on Historic and Cultural Resources

About 800 historic and archeological sites have been reported within the Sale Area (AHRS 2020). Historic structures, cultural sites, and prehistoric archeological sites may be encountered during field-based activities, and these resources could be damaged or destroyed by ground disturbance during exploration, development, and production. If exploration and development occur, activities that could impact historic and cultural resources could include installation and operation of oil and gas facilities including drill pads, roads, airstrips, pipelines, and processing facilities. Ground disturbing damage to archaeological sites could include direct breakage of artifacts, damage to vegetation and thermal regime leading to erosion and deterioration of sites, shifting, or mixing of components in sites resulting in loss of association between artifacts, and damage or destruction of sites by crews collecting artifacts.
Spills and spill cleanup activities can directly disturb and damage archaeological sites and may also have an indirect effect through contamination that would eliminate the possibility of using carbon C^{14} dating methods. Following the Exxon Valdez oil spill, archaeological sites on public lands experienced adverse effects including oiling of the sites, disturbance by clean-up activities, or looting and vandalism (Reger et al. 2000; EVOSTC 2014). Monitoring of the sites over a 7-year period indicated that most of the vandalism that could be linked to the spill occurred before constraints were established over activities of oil spill cleanup personnel. Implementation of protective measures limited additional injury to the sites (Bittner 1996; EVOSTC 2014).

However, from a cumulative perspective, more cultural sites have been disturbed and cultural material removed from the North Slope as the result of scientific studies than has been destroyed or removed through unauthorized collection resulting from oil and gas exploration and development or other construction-related activities (NRC 2003; BLM 2012). As in the past, assessments to identify and protect cultural resources prior to the initiation of surface disturbing activities will be a major factor in reducing future cumulative adverse impacts to cultural resources.

2. Mitigation Measures and Other Regulatory Protections

Because historic and cultural resources are irreplaceable, caution is necessary 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 construction and spill 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 (OHA 2020). The NSB also has specific requirements covering historic and cultural resources under Title 19 of the Municipal Code.

Because of the varying circumstances of occurrence surrounding the location and vulnerability of cultural resources, the significance of future impacts to these resources is difficult to assess in terms of the cumulative case. However, if the protections that are currently in place carry forward, then the cumulative impact would be expected to be minor within the Sale Area. As in the past, assessments to identify and protect cultural resources before initiation of surface disturbing activities is a major factor in reducing future cumulative adverse impacts to cultural resources. A complete listing of mitigation measures is found in Chapter Nine.

H. Reasonably Foreseeable Fiscal Effects on the State and Affected Municipalities and Communities

This section discusses the statewide and local fiscal effects of leasing activities. Leasing and subsequent activity may generate income for state government, with additional benefits that include increased revenue sharing, creation of new jobs, and indirect income multiplier effects. Fiscal effects may be statewide and local.

Crude oil production remains a key revenue generator for the State of Alaska, and production forecasting is an important part of the state’s overall fiscal planning. Previous years of forecasting production have provided useful information to the public on this valuable state resource and guidance to decision makers within and outside the state. Lower oil prices make the task of planning for the state’s future even more critical.

1. Fiscal Effects on the State

Figure 8.12 shows how total state revenue (restricted and unrestricted) has evolved over time, from fiscal year 2010 to 2020. These data, published by the Alaska Department of Revenue (ADOR), are
composed of four main revenue sources: investment, federal, petroleum, and non-petroleum revenues. While petroleum revenues have historically dwarfed other sources of revenue to the state, since fiscal year 2015, the importance of petroleum revenue has decreased compared to other sources of total state revenue. Investment revenue accounts for the largest fraction of total state revenue as of late.

Figure 8.12.—State of Alaska total revenues by revenue sources (restricted and unrestricted), fiscal years 2010 to 2020.

Figure 8.13 shows total revenues by restriction, along with average Alaska North Slope (ANS) price per barrel for fiscal years 2010 to 2020. Unrestricted General Fund (UGF) revenues account for most state revenues until 2014, when oil prices fell precipitously. Since then, unrestricted revenues still account for most state revenues, although that gap has decreased considerably. During the time considered, the highest total state revenue accumulated was in fiscal year 2012 (total of $9.9 billion), which also had the highest recorded average ANS price barrel of $113.00.
Figure 8.13.—Oil and gas-related revenue and price per barrel of Alaska North Slope crude oil, fiscal years 2010 to 2020.

In terms of UGF petroleum revenue, Figure 8.14 below shows state revenues from oil and gas royalties, production tax, petroleum property tax, corporate income tax, and other revenues (i.e., oil and gas hazardous release, and bonuses, interests, and rents) for fiscal years 2010 to 2020. These are net of Alaska Permanent Fund, Public School Trust Fund, and Constitutional Budget Reserve Fund deposits. UGF categories of oil and gas conservation and petroleum special settlements are omitted since no revenue was generated during this period from these sources. Although details are discussed below, it is important to note that although production tax had historically accounted for most unrestricted revenues during this period, royalty revenues have grown increasingly important in the wake of ANS oil price slides. Corporate income tax has also been important historically and is regaining its importance as of late.
Source: (ADOR 2020c, d); Corp = Corporate.

**Figure 8.14.—State of Alaska unrestricted oil and gas revenues, fiscal year 2010 to 2020.**

Restricted petroleum revenues from fiscal years 2010 to 2020 (Figure 8.15), include state revenues from NPR-A rents, royalties, bonuses; royalty payments to the Alaska Permanent Fund (Permanent Fund) and Public School Trust Fund, and Constitutional Budget Reserve Fund deposits. Royalty payments to the Permanent Fund have decreased over time, along with Constitutional Budget Reserve Fund deposit payments. Except for 2017, royalty payment to the Permanent Fund accounted for the highest restricted source of state revenue during this time.
Unrestricted Revenue

Alaska’s economy and state government operations depend heavily on revenues related to oil and gas production. Oil and gas lease sales generate income to state government through royalties, payments of net profits from net-profit-share leases, bonuses, rents, interest, production taxes, petroleum corporate income taxes, and petroleum property taxes. Between statehood in 1959 and fiscal year 2017, petroleum related revenues totaled $210.97 billion (real 2017 dollars). In fiscal year 2018, the oil and gas industry paid $2.44 billion in petroleum related revenues, with $2 billion paid to state government and $439.9 million paid to local governments (ADOR 2018, 64). In fiscal year 2019, petroleum related revenues were $2.62 billion, an increase of $175 million from the previous year. From the $2.62 billion paid to state government, $2.0 billion was allocated to the UGF (ADOR 2019, 20). For fiscal year 2020, petroleum related revenues were $1.70 billion, a decrease of $915 million from the previous year (a drop of 34.9 percent). From the $1.70 billion paid to state government, $1.08 billion was allocated to the UGF (ADOR 2020c, 38).

In December 2020, ADOR released their 10-year revenue forecast for revenue deposited into the UGF based on the forecast of ANS oil prices and oil production. UGF is forecast to be $4.33 billion (including Permanent Fund transfer) for fiscal year 2021 ($861.7 million from petroleum revenue), $4.27 billion in fiscal year 2022 ($808.9 million from petroleum revenue), and 5.48 billion by the end of the forecast period in fiscal year 2030 ($1.20 billion from petroleum revenue; ADOR 2020c, 104). This is based on a forecast of Alaska North Slope oil prices averaging $45.32 per barrel for...
fiscal year 2021, climbing to $57.00 per barrel by fiscal year 2030 (ADOR 2020c, 106). These projections are adjusted annually through ADOR revenue forecasts.

### i. Lease Bonuses and Rentals

Lease bonuses and lease rentals are two components that contribute revenue to the state. Bonus bids are cash payments received by the state to obtain an oil and gas lease. Normally, the state’s sale terms establish the bonus payment as the bid variable so that the bidder offering the highest bonus bid wins the lease being offered. Since 2000, annual revenues from lease bonus payments for all oil and gas lease sales in Alaska have ranged from as low as about $2.5 million in 2005 to as high as $64.9 million in 2014 (Alaska Oil and Gas Competitiveness Review Board 2015; DO&G 2018a). For the Sale Area, annual revenues from lease bonus payments have reached a high of $9.8 million in May 2001, with an average value of $816,467 for the period 2001 through 2019. Since 2013, the Sale Area has not generated any winning bids (DO&G 2020b).

Each lease requires an annual rental payment. Lease rentals are periodic cash payments received by the state to maintain an oil and gas lease and the rights granted under it. The state receives an average of between $20 to $25 million annually in lease rental payments statewide. In calendar year 2019, the state did not collect any revenue in rentals for the Sale Area. The rental rate may not be the same for each lease sale over the 10-year term of this best interest finding, and the rate will be published in the pre-sale notice as discussed in Chapter Two. Sale Area rental rates have ranged between $1 to $3 per acre.

### ii. Royalties

Royalty payments are based on the value and volume of the oil and gas removed from the state leased land and the lease’s royalty rate. Royalties, including bonuses, rents and interest on petroleum production, totaled $675 million in fiscal year 2020 and is forecasted to be $569 million in fiscal year 2021 (ADOR 2020c, 7). For fiscal year 2021, this revenue would represent 66.1 percent of unrestricted oil and gas revenue and 13.1 percent of total UGF revenue (ADOR 2020c, 7 and 8). It is also 47.9 percent of total unrestricted and restricted state oil and gas revenue (ADOR 2020c, 38). The funds received from oil and gas leases including royalties, bonuses, rents and interest, and federal payments on petroleum production was approximately $1.0 billion for fiscal year 2020 (DO&G 2020a).

### iii. Oil and Gas Production Taxes

On the North Slope, an annual tax is levied on the net value of oil and gas production (AS 43.55) with a tax floor based on the gross value. For North Slope producers, the current tax rate is 35 percent of the net value of oil and gas with a minimum tax floor ranging 0 to 4 percent of the gross value depending on the price of Alaska North Slope crude. Net value is equal to gross value at the lease minus the costs of production at the lease. Producers may also apply certain per-barrel tax credits to reduce their tax liability to the minimum tax floor or potentially zero. If the net value is negative, a producer may carry forward the unused costs to reduce tax liability in future years. To encourage new oil and gas production, net value is calculated with a 20 percent reduction in the gross value associated with the new production for the first 7 years of production or when the average annual price of Alaska North Slope oil at the US West Coast is above $70 per barrel for 3 years, whichever occurs first. In fiscal year 2020, the production tax generated $285.1 million in state revenue with $1.89 production tax collected per taxable barrel for ANS production; in fiscal year 2021, ADOR forecasts $171.8 million in state revenue with $1.12 production tax collected per taxable barrel (ADOR 2020c, 43)
iv. Corporate Income Tax

Corporate income taxes must be paid by C corporations in the state for all taxable worldwide income apportioned to the state based on property, production, and sales within the state (AS 43.20). According to the ADOR, in fiscal year 2020, petroleum corporate income tax revenue was -$0.2 million. ADOR estimates that petroleum corporate income tax will be approximately $5 million in fiscal year 2021 and $20 million in fiscal year 2022 (ADOR 2020c, 39).

v. Property Tax

Alaska’s oil and gas property tax is levied on the value of taxable exploration, production, and pipeline transportation property at a rate of 2 percent of the assessed value. In fiscal year 2020, this tax generated gross revenue of $123.0 million for the state with the remaining $456.8 million paid to local governments ($387.9 million to North Slope Borough), and net revenue of $122.9 million for the state. For fiscal year 2021, ADOR has forecasted net oil and gas property tax to be paid to the state to be approximately $115.7 million and $113.2 million for fiscal year 2022 (ADOR 2020c, 39 and 52).

vi. Oil Conservation Surcharge

The Oil and Hazardous Substance Release Prevention and Response Fund was created in 1986 and is intended to be a source of funds that can be drawn upon in the event of a release of a hazardous substance for the abatement of damages (ADOR 2016). Under AS 43.55.201–300, the fund is maintained through a per-barrel tax and is separated into two accounts: one supporting response to a hazardous release and another that supports the prevention of hazardous releases which primarily funds a division at the ADEC (ADOR 2016; McDowell Group 2017). In 2015, the legislature added funding to the Spill Prevention and Response program through a surcharge on refined fuel sales in the state (ADOR 2016). In fiscal year 2019, this tax generated funds amounting to $8.2 million (ADOR 2019, 87). For fiscal years 2020 and 2021, ADOR forecasts approximately $8.2 million for each year (ADOR 2019, 90).

b. Restricted Revenue

A portion of Alaska’s oil and gas revenues are restricted and designated for specific uses. In fiscal year 2020, restricted revenue accounted for 36.5 percent ($621.5 million) of all petroleum revenue, which was $1.70 billion (ADOR 2020c, 38). This was 7.2 percent of total state revenues for fiscal year 2020 (ADOR 2020c, 6 and 38). ADOR expects that in fiscal year 2021, of the $1.19 billion forecasted to be generated from oil and gas activity, $325.4 million, or 27.4 percent, will be restricted revenue (ADOR 2020c, 38). This component will be 3.0 percent of all state revenue for fiscal year 2021 (ADOR 2020c, 6 and 38). This revenue is placed in several funds including the Permanent Fund, the Public School Trust Fund, and the Constitutional Budget Reserve Fund. Additionally, the state is entitled to 50 percent of bonuses, rents, and royalties associated with leasing of lands in the NPR-A (McDowell Group 2017; ADOR 2020c).

i. Alaska Permanent Fund

The Alaska Constitution was amended by public referendum in 1976, dedicating at least 25 percent of all mineral lease rentals, royalties, royalty sale proceeds, federal mineral revenue sharing payments, and bonuses received by the state to the Permanent Fund. Revenues from oil and gas activities go into the state’s General Fund, however, a portion of the revenue is set aside for the Permanent Fund. According to AS 37.13.010, 25 percent of all mineral lease rentals, royalties, royalty sale proceeds, and federal mineral revenue sharing payments received by the state from mineral leases issued on or before December 1, 1979, and 25 percent of all bonuses received by the state from mineral leases issued on or before February 15, 1980, are dedicated to the Permanent
Fund. Also, according to AS 37.13.010, 50 percent of all mineral lease rentals, royalties, royalty sale proceeds, and federal mineral revenue sharing payments received by the state from mineral leases issued after December 1, 1979, and 50 percent of all bonuses received by the state from mineral leases issued after February 15, 1980, are dedicated to the Permanent Fund. Contributions to the Permanent Fund are to be invested in income-producing investments authorized by law. The legislature appropriates portions of the Permanent Fund’s statutory net income to the Permanent Fund Dividend Fund (Dividend Fund), a sub-fund of the state’s general fund created in accordance with AS 43.23.045 and administered by the ADOR. The Dividend Fund is used primarily for the payment of permanent fund dividends to qualified Alaska residents. In addition, the legislature has appropriated a portion of the dividend distribution to fund other activities or operations. In fiscal year 2020, 18.7 percent of total petroleum revenue ($318.9 million) was dedicated to the Permanent Fund (ADOR 2020c, 38). As of November 30, 2020, the total Permanent Fund market value was approximately $69.8 billion (APFC 2020).

ii. Public School Trust Fund

Established under AS 37.14.110–170, the Public School Trust Fund originally consisted of income from the sale or lease of land granted by an Act of Congress on March 15, 1915, but is now primarily funded by a 0.5 percent royalty on receipts connected with the management of State of Alaska Lands (AS 37.14.150), including revenue generated through royalties, mineral lease rentals, the sale of surface rights, and other activity. The principal of this fund, and all capital gains and losses thereon, are perpetually retained in the fund (AS 37.14.110) and the remaining net income of the fund must be used for the state public school program (AS 37.14.140). As of November 30, 2020, the fund’s principal market value was approximately $751.61 million, an increase from the principal fund market value of $688.12 million in fiscal year 2020 (ADOR 2020b).

iii. Constitutional Budget Reserve

The Constitutional Budget Reserve Fund was established November 6, 1990 when voters approved adding Section 17 to Article IX of the Constitution of the State of Alaska. All money received by the state after July 1, 1990, through resolution of disputes about the amount of certain mineral-related income, must be deposited in this fund. The legislature may, under certain conditions, appropriate funds from the Constitutional Budget Reserve to fund the operations of state government (ADOR 2017).

As of November 30, 2020, this fund had a market value of over $1.07 billion, a decrease from $1.98 billion in fiscal year 2020 (ADOR 2020a). In fiscal year 2020, the oil and gas industry paid $281.2 million into the Constitutional Budget Reserve; the expected amount for fiscal year 2021 is $60 million. The fund generated $62.8 million in revenue from investment activities in fiscal year 2020; for fiscal year 2021, ADOR expects approximately $2 million (ADOR 2020c, 9 and 38).

iv. NPR-A Royalties, Rents, and Bonuses

Revenues from royalties, rents and bonuses associated with leasing and production in the NPR-A are split equally between the State of Alaska and United States Government. This restricted revenue first goes to municipalities to minimize impacts associated with NPR-A development in the form of grants administered by Alaska Department of Commerce, Community and Economic Development. Any remaining funds are allocated in accordance with State of Alaska royalty revenue distributions. In fiscal year 2020, $16.4 million was collected from leasing activity and oil production on NPR-A lands, supporting local government operations, youth programs, and infrastructure projects (ADOR 2020c, 38). The projected amount for fiscal year 2021 is $10.8 million (ADOR 2020c, 38).
c. Employment

Estimates of the statewide impacts of oil and gas industry related jobs and wages can vary widely as there is no standard definition of what constitutes the oil and gas industry, or consistent survey methodology used in all assessments. For example, a study by the McDowell Group (2020) used a broader definition of the industry than one typically used for government employment statistics. Government-published statistics for oil and gas employment in Alaska include jobs in companies classified under “oil and gas extraction,” “drilling oil and gas wells,” and “support activities for oil and gas operations” (McDowell Group 2020).

As Figure 8.16 shows, oil and gas industry employment in Alaska peaked on a monthly basis in 2014 with 15,300 employees, which also resulted in the highest annual employment level of 14,800 during the period 2001 to 2018 (McDowell Group 2020, 60). Monthly employment in 2018 peaked at 9,600, while 2018 annual employment was 9,400. This number rose to about 9,900 in 2019 as reported from a different source (DOLWD 2020a, 5). Employment numbers do not necessarily track oil prices annually (Figure 8.17). While employment in the oil and gas sector started to decrease appreciably after 2015, this decrease lasted even after oil prices started increasing from 2016 onward. Between 2011 and 2014, when oil prices were decreasing but still relatively high, employment was steadily increasing (McDowell Group 2020).

Source: (McDowell Group 2020)

Figure 8.16.—Alaska oil and gas industry employment 2001 to 2018.
Employment and wage data for 2018 were analyzed for 17 businesses that comprised the group of “Primary Companies”. The Primary Companies included: Alaska Gasline Development Corporation, Alyeska Pipeline Service Company, BlueCrest Energy Inc., BP Alaska, Brooks Range Petroleum Corporation, Chevron Corporation, ConocoPhillips, Eni Petroleum, ExxonMobil, Furie Operating Alaska, Glacier Oil & Gas Corporation, Hilcorp Energy Company, Marathon Petroleum Corporation, Oil Search (Alaska), Petro Star Inc., Repsol, and Shell Exploration & Production Company. The 17 businesses that comprise the group of Primary Companies directly employed 4,906 workers in Alaska in 2018, including 4,111 Alaska residents, 84 percent of Primary Company employees. These employees received $1.18 billion in wages; Alaska residents received $983 million, 83 percent of the total (McDowell Group 2020, 19).

Economic impact modeling indicates these subsequent cycles of spending supported just under 37,700 indirect and induced jobs in Alaska. Combining direct, indirect, and induced impacts, the oil and gas industry in Alaska supported 41,811 jobs and $3.12 billion in annual payroll in 2018. This estimate does not include jobs and income in Alaska stemming from the expenditure of state and local government oil-related taxes and royalties paid by the oil industry (McDowell Group 2020, 20). For every Primary Company job, there are nine more jobs supported by Primary Company activity in Alaska, and 13 more jobs are supported by oil-related taxes and royalties (McDowell Group 2017, 4).

The Alaska Department of Labor and Workforce Development (DOLWD), in its June 2020 edition of the Alaska Economic Trends, estimates that for 2018 the total wages in the oil and gas industry for Alaska residents was $961.72 million, for 7,566 resident workers (DOLWD 2020a, 7). As Figure 8.18 shows, for 2018, total annual wages generated by the oil and gas industry increased to
$1.38 billion, from $1.31 billion in the previous year (McDowell Group 2020, 61). Total oil and gas employment in Alaska in 2019 is expected to average at 9,880, with 66 percent of these jobs located in the North Slope (DOLWD 2020a, 7). In its October 2020 edition of the Alaska Economic Trends, DOLWD estimates that the number of jobs in the Oil and Gas Extraction category in 2018 was 3,511. The projection for 2028 is 3,624 jobs, representing a loss of 133 jobs (DOLWD 2020b, 7).

Source: (McDowell Group 2020)

Figure 8.18.—Oil and gas industry wages, 2007 to 2018.

i. Workforce Development

The workforce that supports Alaska’s oil and gas industry requires that adequate training opportunities exist and that knowledge of the skills needed are available to those helping guide workforce development. To fill the high demand, Alaska must provide avenues of workforce development that accommodate high paying jobs found in the oil and gas industry. This will put Alaska residents to work in these jobs and provide industry confidence that Alaskans can substantially help meet future labor demands.

Alaska’s trade apprenticeship programs are critical to meeting the needs of the oil and gas industry’s need for skilled workers in Alaska’s oil and gas fields. There are more than 2,000 apprentices being trained in five training centers between Fairbanks and Juneau (Alaska Oil and Gas Competitiveness Review Board 2015). According to the DOLWD, the benefits of registered apprenticeship include higher employment rates, higher wages, and higher rates of Alaska hire. Between 2004 and 2014, new registration in apprenticeship programs had increased by over 50 percent. Approximately 88 percent of the people registered in Alaskan apprentice programs were Alaska residents, therefore the vast majority of their wages are spent in Alaska.
Approximately 11 percent of apprentices work in the natural resources and mining industry; however, the other industries that have active apprentice programs including construction, trade, transportation, and utilities, provide support for the oil and gas industry (Kreiger 2016).

There are several apprenticeship programs available in Alaska for various trades and specialties. Some of these programs include the Alaska Apprenticeship Training Coordinators Association, which offers training for apprentices in the construction trade; Alaska Works for pre-apprenticeship training specializing in training women and military personnel for apprenticeship opportunities; Associated Builders and Contractors Inc. for specialized construction trades; Alaska Vocational Technical Center, Alaska’s Institute of Technology; Alaska Health Care Apprenticeship Consortium; and two programs for maritime training including the Paul Hall Center for Maritime Training and Education, and the Alaska Maritime Apprenticeship Program (AATCA 2020; ABC 2020; AHCAC 2020; AKMAP 2020; AWP 2020; DOLWD 2020c; SIU 2020).

2. Fiscal Effects on Municipalities and Communities

Oil and gas exploration, development, and transportation have been the primary industry and financial source for the North Slope communities since the late 1960s. The oil and gas industry and the associated support industries, including the government sector, have provided the majority of the jobs to the residents of the region in that timeframe as well. As residents have both benefited and grown accustomed to the result of modern capital development on the North Slope, the NSB has transformed to a mixed cash subsistence economy. In addition to the petroleum industry, the NSB has become a dominant economic organization on the North Slope. The NSB taxes the oil and gas facilities and uses the revenues to provide education and a wide array of other public services within its boundaries. The economy and tax base is rooted in the oil and gas industry and it remains strong today. The total assessed value of $22 billion for the NSB in fiscal year 2017 remained consistent through fiscal year 2020 (NSB 2017, 17; 2019a, 16).

a. Property Taxes for the North Slope Borough

Property tax revenues from oil and gas properties typically provide over 90 percent of the taxes levied by the NSB. The revenue has nearly doubled since from 2006 to 2015 due to more increases in assessed value of properties and more property to be taxed (NSB 2015a). The oil and gas industry paid $431.3 million in gross property taxes to the NSB during the 2020 fiscal year, with $387.9 million of that paid to the NSB, and 43.3 million paid to the state (ADOR 2020c, 52).

It has been assumed that decline in production of the North Slope oil fields would result in a decline in property tax revenues. However, as new discoveries are made and additional projects come online, it is anticipated that the increased level of activity will supplement the NSB tax base, the state’s operating budget, and debt reimbursement (NSB 2016).

b. Other Revenue

Alaska Native corporations and the shareholders may benefit from lease sales and any development that results. For example, Kuukpik Corporation owns surface lands within the Sale Area, and the Arctic Slope Regional Corporation (ASRC) owns certain subsurface minerals. Kuukpik Corporation enters into surface access agreements with oil and gas companies operating on its land and collects revenues. Royalties and other oil and gas revenue are paid to ASRC from production and rent where ASRC is the mineral owner in the Sale Area and the NPR-A. Oil and gas revenue from ASRC lands, 70 percent of which are paid to the other 12 Alaska Native Corporations in accordance with section 7(i) of Alaska Native Claims Settlement Act, eventually reach corporation shareholders in the form of shareholder dividend payment (NSB 2015b).
In addition, revenues from exploration and development of oil and gas resources in the Sale Area and elsewhere on the North Slope have added economic stability to local communities. The cumulative economic impacts also apply at the local community level. North Slope communities receive revenue from oil and gas through ownership of lands used by industry, distribution of special funds unique to leases, appropriations for a variety of services from state government, and impact funds from the state’s share of revenues collected from development on federal land. Continuing or expanding those opportunities are dependent on Sale Area oil and gas revenues.

c. Employment

There were approximately 12,056 jobs reported in the NSB in 2018. Approximately 70 percent (or 8,389) of those jobs were in the Prudhoe Bay area. While a very large number of oil and gas industry jobs are based in the NSB, very few of these workers reside in the Borough. The North Slope oil industry infrastructure and work sites are self-contained and hundreds of miles away from most of the Borough’s resident population. Because most workers reside outside of the Borough, employment and wage data are often calculated by place of work (McDowell Group 2020, 26).

The 17 Primary Companies operating in Alaska’s oil and gas industry provided approximately 1,905 jobs and accounted for $507 million in annual wages during 2018 in the NSB. Oil and gas support services companies operating in the NSB provided 4,252 jobs and accounted $411 million in annual wages. Alaska residents held an estimated 2,416 (57 percent) of these North Slope positions and earned $237 million (58 percent) in wages (McDowell Group 2020, 26).

Primary Companies and oil and gas support services companies supported employment for approximately 20 NSB residents with about $1 million in wages and an additional 1,621 jobs generating $95 million in wages are also connected to North Slope oil and gas industry activity (McDowell Group 2020, 26). As exploration occurs, employment opportunities would be added to the state and regional economy. These jobs would not be limited to the oil and gas industry, but would spread throughout the trade, transportation, service, and construction industries.

d. Mitigation Measures and Other Regulatory Protections

Although oil and gas activities could potentially have effects on boroughs and communities in or adjacent to the Sale Area, measures in this best interest finding, along with other regulatory protections, are expected to mitigate potentially negative effects. Positive effects are expected on local governments and economies, employment, personal income, reasonable energy costs, and opportunities for industrial development. Lessees are encouraged 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 how 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 state oil and gas leases. A complete listing of mitigation measures can be found in Chapter Nine.

I. Reasonably Foreseeable Other Effects on North Slope Communities

1. Effects on Access and Local Transportation

The Sale Area and adjacent lands are located within the jurisdictions of several entities, which have varying authorities over oil and gas development activities on those lands as discussed in Chapter Three. The North Slope has undergone changes with respect to local transportation since the 1970s. The community of Nuiqsut was reestablished in 1973, and soon after, the TAPS was built and
production at Prudhoe Bay began. Oil development in Prudhoe Bay included the development and construction of roads, airports, and other supporting infrastructure in the previously undeveloped area.

Construction of access roads in the Sale Area to benefit oil and gas development could impact communities in positive and negative ways. Some negative impacts of permanent roads linking distant communities to the Sale Area would be permanent changes to the characteristic of the landscape, introduction of public access into currently non-easily accessible areas, increase in the overall noise level, and increase in the viability of further development in and surrounding the Sale Area with potential cumulative impacts in the Anaktuvuk Pass and Nuiqsut areas being long-term with both localized and regional benefits (ASCG Incorporated 2005; WHPacific et al. 2016). Permanent road access to villages would reduce transportation costs and consequently would reduce costs for goods and services (WHPacific et al. 2016).

Independent of oil and gas development, the Arctic Strategic Transportation and Resources (ASTAR) program is a partnership between DNR and the NSB. ASTAR seeks to work closely with NSB communities to identify, evaluate, and advance opportunities to enhance the quality of life and economic opportunities in North Slope communities through responsible infrastructure development. ASTAR’s goal is to prioritize community needs and identify infrastructure opportunities that offer the most cumulative benefit and best enhance the quality of life for the region. Of relevance to the Sale Area are potential transportation and utility corridors that could cross the Sale Area to connect Anaktuvuk Pass and Kaktovik with the Dalton Highway. Development of these community transportation corridors could influence future development of oil and gas resources as has been the pattern from previous development (ASTAR 2017; NSB 2018).

An increase in permanent road access may be beneficial to future oil and gas exploration and development in and adjacent to the Sale Area depending on the location of the oil and gas resource. As noted above, additional revenue is allocated to NSB communities with additional oil and gas properties producing hydrocarbons. Permanent road systems could benefit residents of Anaktuvuk Pass, Nuiqsut and other North Slope communities seeking access to traditional subsistence areas now limited to travel by off-road vehicle or snowmachine while access may adversely impact the ability to harvest subsistence resources in the immediate area of the road and other facilities (NRC 2003; NSB 2018).

As more roads are constructed on the North Slope, NSB residents have voiced concerns. Road construction and public access increases competition for and division of subsistence resources with potential increased harvest pressure on wildlife populations. Other concerns are diminishing water and air quality, increased social ills and safety issues, vegetation damage and erosion, and traffic noise and disturbance (NSB 2014). Lease mitigation measures, NSB requirement for new roads under the Title 19 zoning code, and stipulations on permits will help minimize these potential effects.

### 2. Effects on Recreation and Tourism

Tourism may be characterized as business, pleasure, or vacation tourism; and visiting friends and relatives. Of these, business and vacation tourism are the types most affected by oil and gas development. There would be very little, if any, effects on business travel and visiting in communities near the Sale Area. Outdoor recreation and tourism in the Sale Area often originates from the Dalton Highway. It is not expected that oil and gas activities in the Sale Area would affect outdoor recreation other than a potential for mild disturbances from increased traffic to new oil and gas developments. It is assumed oil and gas activity areas would be generally avoided by visitors.
A major spill could have an impact on recreation as it has in other parts of Alaska and the United States. Spills and cleanup activities near the Dalton Highway in summer could temporarily delay tourist traffic. An analysis of the 2010 BP Macondo oil spill in the Gulf of Mexico, which included 11 case studies of other oil spills, concluded the average range of oil spill impacts to tourism was 12 to 28 months (OE 2010). It is highly unlikely an oil spill of the magnitude of the spills noted above would occur in the Sale Area; however, containment and control of spills of moderate size may have impacts on recreational users.

3. Effects on Gates of the Arctic National Park and Preserve

The National Park Service (NPS) has expressed concern that oil and gas activities in the Sale Area could affect wilderness character and night skies in Gates of the Arctic National Park and Preserve (GAAR). Oil and gas developments in the Sale Area could affect solitude, sense of isolation and disconnectedness, and the viewshed within GAAR through noise from vehicle traffic on roads or aircraft overflights, and visibility of infrastructure outside of GAAR. The Dalton Highway and TAPS currently affect the GAAR viewshed within 9.3 miles (15 kilometers) primarily along the eastern edge of GAAR, south of Atigun Pass and well south of the Sale Area (Pace et al. 2017). There are currently no viewshed impacts from outside the wilderness areas along the northern boundary of GAAR, except for impacts to lands surrounding the community of Anaktuvuk Pass from buildings and infrastructure in Anaktuvuk Pass (Pace 2020). Noise effects from aircraft overflights may be detectable for great distances depending on flight paths, terrain, and wind conditions. Traffic noise from roads may be detectible within 3.1 to 3.7 miles (5 to 6 kilometers) but typically attenuates to background levels within 1.2 to 1.9 miles (2 to 3 kilometers; Pace et al. 2017).

Management policies direct the NPS to preserve the natural lightscapes of parks which can be affected by light pollution from sky glow or glare. Sky glow is brightening of the night sky from anthropogenic light scattered and reflected by air molecules and atmospheric aerosols. Glare is direct shining of bright light that results in a high ratio of luminance between the source and the task or object that is being observed. Light trespass occurs when outdoor lighting extends beyond its intended task and intrudes into surrounding areas. The landscape in the Sale Area is smooth and rolling with visibility over great distances typified by low topographic features along wide river valleys, with a notable string of low bluffs including Hatbox Mesa, Tuktu Bluff, Gunsight Mountain, Banded Mountain, and Table Top. An analysis of potential light trespass from unmitigated oil and gas activities on State of Alaska lands in the Sale Area along the northern GAAR indicate that lighting along the low bluffs and in the Anaktuvuk and Itkillik river valleys would be visible over about 29 percent of the GAAR northern boundary (Figure 8.19). Unshielded lighting in up to 53 percent of the Sale Area would not be visible from GAAR. Attention to lighting design and use of best lighting management practices and minimizing flaring could mitigate most light trespass impacts to GAAR. Recommended lighting practices for oil and gas include: preparing a lighting plan, use audiovisual warning system technology for hazard lighting on structures, use full cutoff luminaires, direct lights properly to eliminate light spill and trespass, use amber instead of bluish-white lighting, minimize lighting usage during construction and operations, use vehicle-mounted lights or portable light towers for nighttime maintenance activities, use an enclosed combustor if the need to flare arises (Betchkal 2020).
Figure 8.19.—Potential for light trespass from the state lands in the Sale Area on GAAR.

Source: (Betchkal 2020)
J. References


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Chapter Nine: Mitigation Measures

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Operations will be conditioned by mitigation measures that are attached to all leases issued and are binding on the lessee. These measures were developed to mitigate potential effects of lease-related activities, considering all information made known to the director. Additional measures may be imposed when the lessee submits a proposed plan of operations (11 AAC 83.158(e) and 11 AAC 83.346(e)) for exploration, production, development, or transportation uses, or in rights-of-way for other pipelines. The director may consult with local government organizations and other agencies in implementing the mitigation measures below. The lessee is subject to applicable local, state, and federal laws and regulations, as amended.

The director may grant exceptions to these mitigation measures upon a showing by the lessee that compliance with the mitigation measure is not practicable and that the lessee will undertake an equal or better alternative to satisfy the intent of the mitigation measure. Requests and justifications for exceptions must be included in the plan of operations application as specified by the application instructions, and decisions of whether to grant exceptions will be made during the plan of operations review.

A. Mitigation Measures

1. Facilities and Operations
   a. Oil and gas facilities, including pipelines, will be designed using industry-accepted engineering codes and standards. Technical submittals to the Division of Oil and Gas (DO&G) that reflect the “practice of engineering,” as defined by AS 08.48.341, must be sealed by a professional engineer registered in the State of Alaska.
   b. A plan of operations will be submitted and approved before conducting exploration, development, or production activities in accordance with 11 AAC 83.
   c. Facilities will be designed and operated to minimize sight and sound impacts in areas of high residential, recreational, and subsistence use and important wildlife habitat.
   d. The siting of facilities, other than docks, roads, utility, and pipeline crossings, is prohibited within 500 feet of all fish bearing waterbodies and 1,500 feet from all current surface drinking water sources.
   e. Notwithstanding (d) above, the siting of facilities is prohibited within 1/2 mile of the banks of the Colville, Canning, Sagavanirktok, Shaviovik, Kadleroshilik, and Kuparuk, rivers as measured from the ordinary high-water mark. Facilities may be sited, on a case-by-case basis, within the 1/2 mile buffer if the lessee demonstrates that siting of such facilities outside this buffer zone is not feasible or prudent, or that a location within the buffer is environmentally preferable.
   f. Impacts to important wetlands will be minimized to the satisfaction of the director, in consultation with the Alaska Department of Fish and Game (ADF&G) and Alaska Department of Environmental Conservation (ADEC). The director will consider whether facilities are sited in the least sensitive areas.
   g. Exploration roads, pads, and airstrips will be temporary and constructed of ice. Use of gravel roads, pads, and airstrips may be permitted on a case-by-case basis by the director, in consultation with Division of Mining, Land, and Water (DMLW) and ADF&G.
h. Road and pipeline crossings will be aligned perpendicular or near perpendicular to watercourses.

i. Pipelines:
   i. In areas with above ground placement, pipelines will be designed, sited, and constructed to allow for the free movement of wildlife and to avoid significant alteration of caribou and other large ungulate movement and migration patterns.
   ii. At a minimum, above ground pipelines will be elevated 7 feet, as measured from the ground to the bottom of the pipeline, except where the pipeline intersects a road, pad, or a ramp installed to facilitate wildlife passage. A lessee will consider snow depth in relation to pipe elevation to ensure adequate clearance for wildlife.
   iii. Pipelines and gravel pads will facilitate the containment and cleanup of spilled fluids.
   iv. Pipelines must be located and constructed in consultation with ADF&G and the local borough.
   v. Pipelines will use existing transportation corridors wherever possible and be buried where soil and geophysical conditions permit.

j. Upon abandonment of material sites, drilling sites, roads, buildings or other facilities, such facilities must be removed, and the site rehabilitated to the satisfaction of the state, unless the state, in consultation with any non-state surface owner, as applicable, determines that such removal and rehabilitation is not in the state’s interest.

k. Material sites required for exploration and development activities will be:
   i. restricted to the minimum size necessary to develop the field efficiently and with minimal environmental damage,
   ii. designed and constructed to function as water reservoirs for future use where practicable, and
   iii. located outside of the active floodplain of a watercourse unless the DMLW director, after consultation with ADF&G, determines that there is no practicable alternative, or that a floodplain site would enhance fish and wildlife habitat after mining operations are completed and that site is closed.

l. The director may include plan stipulations if necessary to reduce or eliminate adverse impacts to fish and wildlife or to protect the environment.

2. Fish, Wildlife, and Habitat

a. The lessee will consult with the North Slope Borough (NSB) before proposing the use of explosives for seismic surveys. The director may approve the use of explosives for seismic surveys after consultation with the NSB.

b. Any water intake structures in fish bearing or non-fish bearing waters will be designed, operated, and maintained to prevent fish entrapment, entrainment, or injury. All water withdrawal equipment must be equipped and must use fish screening devices approved by ADF&G.
c. Removal of snow from fish-bearing rivers, streams, and natural lakes is subject to prior written approval by ADF&G. Compaction of snow cover overlying fish-bearing waterbodies is prohibited except for approved crossings. If ice thickness is not sufficient to facilitate a crossing, then ice or snow bridges may be required.

d. No facilities will be sited within 1/2 mile of identified Dolly Varden overwintering and/or spawning areas on the Canning, Kavik, Shaviovik, Echooka, Ivishak, Saviukviayak, Anaktuvuk, Kanayut, and Nanushuk rivers, and on May, Cobblestone, Upper Section, Lower Section, and Accomplishment creeks. Notwithstanding the previous sentence, road and pipeline crossings may only be sited within these buffers if the lessee demonstrates to the satisfaction of the director and ADF&G in the course of obtaining their respective permits, that either (1) the scientific data indicate the proposed crossing is not within an overwintering or spawning area; or (2) the proposed road or pipeline crossing will have no significant adverse impact to Dolly Varden overwintering or spawning habitat.

e. Bears:

i. For projects in proximity to areas frequented by bears, the lessee is required to prepare and implement a human-bear interaction plan designed to minimize conflicts between bears and humans. The plan will include measures to:

A. minimize attraction of bears to facility sites;
B. organize layout of buildings and work areas to minimize interactions between humans and bears;
C. warn personnel of bears near or on facilities and the proper actions to take;
D. if authorized, deter bears from the drill site;
E. provide contingencies in the event bears do not leave the site;
F. discuss proper storage and disposal of materials that may be toxic to bears; and
G. provide a systematic record of bears on the site and in the immediate area.

ii. A lessee must consult with ADF&G before commencing any activities to identify the locations of known brown bear den sites that are occupied in the season of proposed activities.

iii. Exploration and production activities will not be conducted within 1/2 mile of occupied brown bear dens unless alternative mitigation measures are approved by ADF&G.

iv. A lessee who encounters an occupied brown bear den not previously identified by ADF&G will report it to the Division of Wildlife Conservation, ADF&G, within 24 hours. The lessee will avoid conducting mobile activities within 1/2 mile from discovered occupied dens unless alternative mitigation measures are approved by the director, with concurrence from ADF&G. Non-mobile facilities will not be required to relocate.

f. Permanent, staffed facilities will be sited outside of identified white-fronted goose, tundra swan, and yellow-billed loon nesting and brood rearing areas.
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3. Subsistence and Sport Harvest Activities

a. Lease-related use may be restricted, if necessary, to prevent unreasonable conflicts with local subsistence, sport fish, or nonlocal and nonresident wildlife harvest activities. Reasonable access to subsistence areas, as defined in Section B, will be maintained unless reasonable alternative access is provided to subsistence users. The lessee will consult the NSB, nearby communities, and native organizations for assistance in identifying and contacting local subsistence users.

b. Before submitting a plan of operations that has the potential to disrupt subsistence activities, the lessee will consult with the potentially affected subsistence communities, and the NSB (collectively "parties") to discuss the siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. The parties will also discuss the reasonably foreseeable effect on subsistence activities of any other operations in the area that they know will occur during the lessee's proposed operations. Through this consultation, the lessee will make reasonable efforts to ensure that exploration, development, and production activities are compatible with subsistence hunting and fishing activities and will not result in unreasonable interference with subsistence harvests.

c. Exploratory drilling operations may be restricted during the fall caribou migration (August 1 through October 31) in the Chandler, Nanushuk, Itkillik, Kuparuk, and Anaktuvuk river valleys to allow for subsistence hunting.

d. Exploration activities may be restricted during fall caribou migration (August 1 through October 31); and the siting of permanent facilities, except for roads or pipelines, will be prohibited in the Chandler, Anaktuvuk, Nanushuk, Itkillik, and Kuparuk river valleys, unless the lessee demonstrates to the satisfaction of the director, in consultation with the NSB, that the development will not preclude reasonable subsistence user access to caribou.

4. Fuel, Hazardous Substances, and Waste

a. The lessee will ensure that secondary containment is provided for the storage of fuel or hazardous substances and sized as appropriate to container type and according to governing regulatory requirements in 18 AAC 75 and 40 CFR 112. Containers with an aggregate
storage capacity of greater than 55 gallons that contain fuel or hazardous substances will not be stored within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source.

b. During equipment storage or maintenance, the lessee will ensure that the site is protected from leaking or dripping fuel and hazardous substances by the placement of drip pans or other surface liners designed to catch and hold fluids under the equipment, or by creating an area for storage or maintenance using an impermeable liner or other suitable containment mechanism.

c. During fuel or hazardous substance transfer, the lessee will ensure that a secondary containment or a surface liner is placed under all container or vehicle fuel tank inlet and outlet points, hose connections, and hose ends. Appropriate spill response equipment, sufficient to respond to a spill of up to 5 gallons, must be on hand during any transfer or handling of fuel or hazardous substances.

d. The lessee will ensure that vehicle refueling will not occur within the annual floodplain, except as addressed and approved in the plan of operations. This measure does not apply to water-borne vessels.

e. The lessee will ensure that all independent fuel and hazardous substance containers are permanently marked with the contents and the lessee’s or contractor’s name.

f. The lessee will ensure that waste from operations is reduced, reused, or recycled to the maximum extent practicable. Garbage and domestic combustibles must be incinerated whenever possible or disposed of at an approved site in accordance with 18 AAC 60.

g. Proper disposal of garbage and putrescible waste is essential to minimize attraction of wildlife. The lessee must use the most appropriate and efficient method to achieve this goal. The primary method of garbage and putrescible waste is prompt, on-site incineration in compliance with State of Alaska air quality regulations. The secondary method of disposal is on-site frozen storage in animal-proof containers with backhaul to an approved waste disposal facility. The tertiary method of disposal is on-site non-frozen storage in animal proof containers with backhaul to an approved waste disposal facility. Daily backhauling of non-frozen waste is required unless safety considerations prevent it.

h. New solid waste disposal sites, other than for drilling waste, will not be approved or located on state property for exploration.

i. The preferred method for disposal of muds and cuttings from oil and gas activities is by underground injection. The lessee will ensure that drilling mud and cuttings will not be discharged into lakes, streams, rivers, or wetlands. On-pad temporary cuttings storage may be allowed as necessary to facilitate annular injection and backhaul operations.

5. Access

a. Exploration activities must be supported only by ice roads, winter trails, existing road systems, or air service. Wintertime off-road travel across tundra and wetlands may be approved in areas where snow and frost depths are sufficient to protect the ground surface.

b. Summertime off-road travel across tundra and wetlands may be authorized subject to time periods and vehicle types approved by DMLW.
c. Emergency exceptions may be granted by the director of DMLW, or the director of DO&G, if it is determined that travel can be accomplished without damaging vegetation or the ground surface on a site-specific basis.

d. Public access to, or use of, the lease area may not be restricted except within the immediate vicinity of drill sites, buildings, and other related structures. Areas of restricted access must be identified in the plan of operations.

6. Historic, Prehistoric, and Archaeological Sites

a. Before the construction or placement of any structure, road, or facility supporting exploration, development, or production activities, the lessee must conduct an inventory of historic, prehistoric, and archeological sites within the area, including a detailed analysis of the effects that might result from that construction or placement.

b. The inventory of historic, prehistoric, and archeological sites must be submitted to the director and the Office of History and Archeology (OHA) who will coordinate with the NSB for review and comment. If an historic, prehistoric, or archeological site or area could be adversely affected by a lease activity, the director, after consultation with OHA and the NSB, will direct the lessee as to the course of action to take to avoid or minimize adverse effects.

c. If a site, structure, or object of historic, prehistoric, or archaeological significance is discovered during lease operations, the lessee will report the discovery to the director as soon as possible. The lessee will make all reasonable efforts to preserve and protect the discovered site, structure, or object from damage until the director, after consultation with the OHA and the NSB, has directed the lessee on the course of action to take for its preservation.

7. Hiring Practices

a. The lessee is encouraged to employ local and Alaska residents and contractors, to the extent they are available and qualified, for work performed in the lease area. The lessee will submit, as part of the plan of operations, a hiring plan that will include a description of the operator’s plans for partnering with local communities to recruit, hire, and train local and Alaska residents and contractors to the extent allowable under state and federal law. As a part of this plan, the lessee is encouraged to coordinate with employment and training services offered by the State of Alaska and local communities to train and recruit employees from local communities.

b. A plan of operations application must describe the lessee’s past and prospective efforts to communicate with local communities and interested local community groups.

c. A plan of operations application must include a training program
   i. for all personnel including contractors and subcontractors;
   ii. designed to inform each person working on the project of environmental, social, and cultural concerns that relate to that person’s job;
   iii. using methods to ensure personnel understand and use techniques necessary to preserve geological, archeological, and biological resources; and
   iv. designed to help personnel increase their sensitivity and understanding of community values, customs, and lifestyles in areas where they will be operating.
B. Definitions

**Facilities** – Any structure, equipment, or improvement to the surface, whether temporary or permanent, including, but not limited to, roads, pads, pits, pipelines, power lines, generators, utilities, airstrips, wells, compressors, drill rigs, camps, and buildings.

**Hazardous substance** – As defined under 42 USC 9601 – 9675 (Comprehensive Environmental Response, Compensation, and Liability Act of 1980).

**Important wetlands** – Those wetlands that are of high value to fish, waterfowl, and shorebirds because of their unique characteristics or scarcity in the region or that have been determined to function at a high level using the hydrogeomorphic approach.

**Minimize** – To reduce adverse impacts to the smallest amount, extent, duration, size, or degree reasonable in light of the environmental, social, or economic costs of further reduction.

**Plan of operation** – A lease plan of operations under 11 AAC 83.158 and a unit plan of operations under 11 AAC 83.346.

**Practicable** – Feasible in light of overall project purposes after considering cost, existing technology, and logistics of compliance with the mitigation measure.

**Reasonable access** – Access using means generally available to subsistence users.

**Secondary containment** – An impermeable diked area, portable impermeable containment structure, or integral containment space capable of containing the volume of the largest independent container. The containment will, in the case of external containment, have enough additional capacity to allow for local precipitation.

**Temporary** – No more than 12 months.