National Petroleum Reserve-Alaska

FINAL

Integrated Activity Plan/ Environmental Impact Statement

Volume 6
Appendices, Glossary, Bibliography

Prepared by:

U.S. Department of the Interior
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In cooperation with:

North Slope Borough
U.S. Bureau of Ocean Energy Management
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November 2012

How the IAP/EIS is Organized

VOLUME 1

Chapter 1 – Introduction: Summarizes the purpose of and need for this IAP/EIS and decisions to be made.

Chapter 2 – Alternatives: Describes and compares proposed management alternatives.

Chapter 3 – Affected Environment: Presents existing natural and socioeconomic resources in the NPR-A and trends, including those associated with climate change.

VOLUME 2

Chapter 4 – Environmental Consequences (sections 4.1 – 4.4): Provides the assumptions upon which the impact analysis rests and evaluates impacts of Alternatives A and B-1 on resources and uses in the NPR-A relevant to making a decision among the alternatives.

VOLUME 3

Chapter 4 – Environmental Consequences continued (sections 4.5 – 4.7): Evaluates impacts of Alternatives B-2 (preferred alternative), C, and D on resources and uses in the NPR-A relevant to making a decision among the alternatives.

VOLUME 4

Chapter 4 – Environmental Consequences continued (sections 4.8 – 4.13): Evaluates the cumulative impacts on resources and uses in the NPR-A and other effects relevant to making a decision among the alternatives.

VOLUME 5

Chapter 5 – Consultation and Coordination: Describes public and government (including tribal) consultation undertaken for this plan and the development of alternatives and lists the plan's preparers.

Chapter 6 – Comments and Responses: Presents public comments on the Draft IAP/EIS and responses to the comments.

VOLUME 6

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Appendix A: Alaska National Interest Land Conservation Act (ANILCA) Section 810 Analysis of Subsistence Impacts

This Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) is a comprehensive land use plan for the over 22 million acres of land managed by the BLM in the National Petroleum Reserve in Alaska (NPR-A). The BLM completed a plan for the Northeast NPR-A (4.6 million acres) in 1998. The BLM amended this plan from 2003-2005 and completed a Final Supplemental Plan for the Northeast NPR-A in May 2008. A proposal by Conoco-Philips Alaska, Inc., for oil development in the Northeast NPR-A and the Colville River Delta resulted in the completion of the Alpine Satellite Development Plan in 2004. The BLM also completed a plan for the Northwest NPR-A in 2004, and in 2005, the BLM initiated a plan for South NPR-A that was discontinued in 2007.

Chapters 3 (Affected Environment) and 4 (Environmental Consequences) of the NPR-A Integrated Activity Plan/Environmental Impact Statement provide detailed descriptions of the affected environment of the planning area and the potential adverse effects of the various alternatives to subsistence and to subsistence resources. This appendix uses the detailed information presented in the IAP/EIS to evaluate the potential impacts to subsistence uses pursuant to section 810(a) of the Alaska National Interest Land Conservation Act (ANILCA).

A.1 Subsistence Evaluation Factors

Section 810(a) of ANILCA, 16 USC § 3120, requires that an evaluation of subsistence uses and needs be completed for any federal determination to “withdraw, reserve, lease, or otherwise permit the use, occupancy or disposition of public lands.” As such, an evaluation of potential impacts to subsistence uses under ANILCA § 810(a) must be completed for the NPR-A IAP/EIS. ANILCA requires that this evaluation include findings on three specific issues:

- The effect of use, occupancy, or disposition on subsistence uses and needs;
- The availability of other lands for the purpose sought to be achieved; and
- Other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes (16 USC § 3120).

The evaluation and findings required by ANILCA § 810 are set out for each of the five alternatives considered in the NPR-A IAP/EIS.

A finding that the proposed action may significantly restrict subsistence uses imposes additional requirements, including provisions for notices to the State of Alaska and appropriate regional and local subsistence committees, a hearing in the vicinity of the area involved, and the making of the following determinations, as required by § 810(a)(3):

- Such a significant restriction of subsistence uses is necessary and consistent with sound management principles for the utilization of the public lands;
- The proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of use, occupancy, or other disposition; and,
- Reasonable steps will be taken to minimize adverse effects upon subsistence uses and resources resulting from such actions.

To determine if a significant restriction of subsistence uses and needs may result from any one of the alternatives discussed in the NPR-A IAP/EIS, including their cumulative effects, the following three factors in particular are considered:

- The reduction in the availability of subsistence resources caused by a decline in the population or amount of harvestable resources;
- Reductions in the availability of resources used for subsistence purposes caused by alteration of their normal locations and distribution patterns; and
- Limitations on access to subsistence resources, including from increased competition for the resources.

A significant restriction to subsistence uses may occur in at least two instances:

1. When an action substantially reduces populations or their availability to subsistence users, and,
2. When an action substantially limits access by subsistence users to resources.

Chapter 3 (Affected Environment) of the NPR-A IAP/EIS provides information on areas and resources important for subsistence use, and the degree of dependence of affected villages on different subsistence resource populations. Chapter 4 (Environmental Consequences) provides much of the data on levels of reductions and limitations under each alternative, and is used to determine whether the action would cause a significant restriction to subsistence uses. The information contained in the NPR-A IAP/EIS is the primary data used in this analysis.

A subsistence evaluation and findings under ANILCA § 810 must also include a Cumulative Impacts analysis. Section A.2, below, begins with evaluations and findings for each of the five alternatives discussed in the NPR-A IAP/EIS. Finally, the cumulative case, as discussed in Chapter 4 (Environmental Consequences) of the NPR-A IAP/EIS, is evaluated. This approach helps the reader to separate the subsistence restrictions that would potentially be caused by activities proposed under the five alternatives from those that would potentially be caused by past, present, and future activities that could occur, or have already occurred, in the surrounding area.

When analyzing the effects of the five alternatives, particular attention is paid to those communities who have the potential to be most directly impacted by the proposed actions—Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright. These communities are located within or adjacent to the NPR-A. The cumulative analysis expands the area of potential impact beyond the planning area to include areas in which activities could occur that would impact subsistence users of NPR-A and the subsistence resources that rely upon NPR-A habitat.

In addition to ANILCA, Environmental Justice, as defined in Executive Order 12898, also calls for an analysis of the effects of federal actions on minority populations with regard to subsistence uses. Specifically, Environmental Justice is:

> The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.

Section 4-4 of Executive Order 12898 regarding the Subsistence Consumption of Fish and Wildlife requires federal agencies to collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence purpsoes, and to communicate to the public any risks associated with the consumption patterns. To this end, the subsistence analyses of all alternatives, located in Chapter 4 (Environmental Consequences) of the NPR-A IAP/EIS, have been reviewed and found to comply with Environmental Justice.

A.2 ANILCA § 810(a) Evaluations and Findings for All Alternatives and the Cumulative Case

The following evaluations are based on information relating to the environmental and subsistence consequences of Alternatives A through D, and the cumulative case as presented in Chapter 4 (Environmental Consequences) of the NPR-A IAP/EIS. The stipulations and required operating procedures/best management practices discussed in Chapter 2 (Alternatives) of the NPR-A IAP/EIS are also considered for the alternatives to which they apply. The evaluations and findings focus on potential impacts to the subsistence resources themselves, as well as access to resources, and economic and cultural issues that relate to subsistence use.

A.2.1 Evaluation and Findings for Alternative A (No-action Alternative)

Alternative A of the NPR-A IAP/EIS is the no-action and is comprised of decisions established in the current records of decision for the Northwest NPR-A (2004) and the Northeast Supplemental IAP (2008). Selection of this alternative would result in a continuation of the BLM's existing management practices in the NPR-A. Alternative A is in effect the preferred alternative from the previous 2004 and 2008 EISs, and as such, a subsistence evaluation as required by ANILCA § 810 has already been completed. However, the 2004 and 2008 IAP/EISs were limited to an analysis of the Northeast and Northwest NPR-A, while the current NPR-A IAP/EIS considers the entire NPR-A. Nevertheless, the evaluation and findings presented here reaffirm the previous conclusion that impacts to subsistence uses as a result of this alternative would be minimal.

A.2.1.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

Under Alternative A, 57 percent (13 million acres) of the National Petroleum Reserve in Alaska could be offered in future oil and gas lease sales. The Required Operating Procedures and lease stipulations defined in the records of decision for the Northeast

Supplemental IAP/EIS (2008) and the Northwest IAP/EIS (2004) would remain in effect. Approximately 2 million acres of the available land would remain deferred from leasing until 2014 or 2018. Teshekpuk Lake and its islands would remain unavailable for leasing. More than 9 million acres in the southern part of NPR-A have not been the subject of an IAP and no oil and gas leasing would occur for these lands in southern NPR-A under Alternative A. A corridor for infrastructure associated with offshore development in the Chukchi Sea could be accommodated.

The analysis of Alternative A on subsistence uses presented in section 4.3.13 ("Subsistence" Alternative A in Volume 2) considers the effects of non-oil and gas activities, the effects of oil and gas activities, the effects of oil spills, and the effectiveness of the stipulations required by the BLM. The analysis concludes that the no-action alternative would have a negligible effect on subsistence species and on access to subsistence resources, and that mitigation measures developed by the BLM in conjunction with local communities would serve to minimize, to the extent possible, impacts to subsistence use by the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, or Wainwright.

Effects to subsistence resources by non-oil and gas activities consist primarily of those actions associated with research. Numerous studies are conducted on a year-round basis on the North Slope, including aerial surveys by fixed-wing aircraft or helicopter, or ground surveys on foot or by off-highway vehicle, all of which have the potential to disturb animals. The most frequent complaint voiced by local subsistence users is that a large amount of aerial disturbance to animals occurs each field season in conjunction with scientific studies (Subsistence Advisory Panel Minutes, November 16, 2011 meeting and August 22, 2002 meeting). Many of the scientific studies that currently occur are a result of stipulations imposed on oil and gas activities in the planning area; however, these same mandatory stipulations serve to minimize the potential effects of conducting research. Based on the analysis presented in Chapter 4 (Environmental Consequences), the effects of non-oil and gas activities on the species utilized by subsistence users are expected to be localized and short-term, and to have no regional population effects.

Oil and gas-related activities allowed under the no-action alternative include seismic exploration, exploratory drilling, and development/production. Each of these activities has the potential to displace animals, with exploration potentially causing temporary displacement in the area of activity, and development/production potentially causing multi-year displacement during construction and until the animal becomes habituated to the resultant infrastructure. Access by subsistence users could be impacted if the animals they wish to hunt have been displaced to areas much farther from their normal hunting grounds. However, many of the stipulations and ROPs in the 2004 and 2008 records of decision would minimize the effects of oil and gas activities on animal populations, their range, and access to hunting areas by subsistence users (see section 4.3.13.3, "Effectiveness of Stipulations and Required Operating Procedures" in Volume 2).

Oil spills have the potential to impact subsistence species as well as subsistence harvest patterns, depending on the amount and the location of the spill. Small spills are unlikely to cause great damage, especially if contained on land. Large spills are unlikely to occur during the exploration phase of oil development, but could occur once production infrastructure and facilities were in place. Several stipulations and required operating procedures pertaining to spills and spill response are included under the no-action alternative; they serve to reduce the potential impacts of oil spills to subsistence species and use.

A.2.1.2 Evaluation of the Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act of 1976, as amended, gave the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. In 1980, Congress granted the authorization for petroleum production to occur and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Reserve. The purpose of the NPR-A IAP/EIS is to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses, and to ensure that BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Alternative A would constitute a continuation of the BLM's existing management practices in the NPR-A. No current BLM IAP decisions are effective for the portions of the NPR-A outside of the Northeast and Northwest NPR-A planning areas. State and Native corporation lands cannot be considered in a BLM plan, and under BLM policy other BLM lands outside of Alaska are not considered under ANILCA.

A.2.1.3 Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. However, neither of these alternatives would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Reserve.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous records of decision allowed the BLM to enter into contracts with several oil companies by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, "Alternatives Considered but Eliminated from Detailed Analysis" in Volume 1 of this IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.1.4 Findings

Alternative A would not significantly restrict subsistence uses and needs. The impacts to subsistence resources and access discussed above would be minimal, or would be adequately mitigated by special area designation and stipulations under which the lessee/permittee must operate. This finding applies to Anaktuvuk Pass, Atqasuk, Barrow, Wainwright, Nuiqsut, and Point Lay.

A.2.2 Evaluation and Findings for Alternative B-1

Alternative B-1, including its stipulations and best management practices, emphasizes the protection of surface resources while making nearly 11 million acres of federally owned subsurface (48 percent of the total in the NPR-A) immediately available for oil and gas leasing. It would enlarge three existing Special Areas and create one new Special Area. Alternative B-1 would make approximately 3.1 million acres of a proposed enlarged Teshekpuk Lake Special Area and approximately 8.2 million acres in southwestern NPR-A unavailable for leasing. Major coastal waterbodies would be unavailable for leasing and permanent non-subsistence infrastructure prohibited, with exceptions for a subsurface pipeline under the Wainwright Inlet/Kuk River and for activities and infrastructure necessary to develop existing leases. This alternative would therefore protect subsistence resources and access in critical use areas as well as protecting the wilderness characteristics of the lands. Alternative B-1 would also recommend that 12 rivers be designated for inclusion in the National Wild and Scenic Rivers System. Lands with particularly high surface resource values would receive special protection measures.

A.2.2.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

The analysis of Alternative B-1 on subsistence uses is presented in section 4.4.13 (“Alternative B-1, Subsistence”). This analysis considers the effects of non-oil and gas activities, the effects of oil and gas activities, the effects of oil spills, and the effectiveness of the associated stipulations and best management practices as presented by the BLM. The analysis concludes that the effect of Alternative B-1 on subsistence uses would be less than that of Alternative A. Effects would remain localized and would not significantly affect subsistence species, access to subsistence species, or subsistence use by the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, or Wainwright.

At issue in this evaluation are the differences between Alternative A and Alternative B-1. The smaller amount of oil and gas development projected for Alternative B-1 compared to Alternative A would result in fewer disturbances to subsistence resources, although there are subtle differences among North Slope communities concerning how oil and gas development under Alternative B-1 would impact subsistence uses. Alternative B-1 primarily differs from the no-action alternative in the following regards:

- By making unavailable for leasing and restricting non-subsistence development in coastal waterbodies and in much of a greatly enlarged Teshekpuk Lake Special Area, Alternative B-1 provides significantly more security for key subsistence species and use areas than Alternative A. Making much of the Teshekpuk Lake Special Area unavailable for leasing reduces the risk of direct and indirect impacts to subsistence harvests of Teshekpuk Caribou Herd in Nuiqsut, Barrow, Atqasuk, and Anaktuvuk Pass.
- Alternative B-1 would make the upper portion of the Kasegaluk Lagoon unavailable for leasing and the Kasegaluk Lagoon Special Area would be 77 percent larger than it would be under Alternative A. This provides distinctly more protection to core subsistence use areas for the communities of Point Lay and Wainwright.
- Alternative B-1 provides for a 1.6-million-acre Peard Bay Special Area and prohibits leasing in Peard Bay itself. This provides distinctly more protection to subsistence use areas for the communities of Wainwright, Barrow, and Atqasuk.

- Coastal waterbodies, including Admiralty Bay, Dease Inlet, and Elson Lagoon that are important for Barrow and, to a lesser extent, for Atqasuk would be unavailable for leasing under Alternative B-1.
- The lower sections of both the Chipp and Ikpikpuk rivers and much of the lower section of the Topagaruk River would be unavailable for leasing under Alternative B-1, which are harvest areas important to subsistence users from Barrow.
- Under Alternative B-1, Nuiqsut's subsistence use area would be better protected because Fish Creek, all of the Teshekpuk Caribou Herd's core calving and insect relief area and important waterfowl habitat in the Teshekpuk Lake area, and the Kogru River would be unavailable for leasing.
- Alternative B-1 provides larger setbacks for portions of the Colville, Ikpikpuk, Kikiakrorak, Kogosukruk, and Titalik rivers.
- Alternative B-1 extends the coastal strip between the Kogru River and Tangent Point to 1 mile inland, instead of three-quarters of a mile, in order to protect molting geese habitat as well as summer shoreline habitat for polar bears, walrus, and seals.
- Unlike Alternative A, Alternative B-1 includes a provision (best management practice H-3) that minimizes impacts to important subsistence species by prohibiting employees of the oil and gas industry or other permitted activities to hunt or trap while working. This measure addresses a key concern of subsistence hunters, which is the encroachment of and competition for resources posed by outside hunters.
- Unlike Alternative A, Alternative B-1 makes available the northwest corner of southern NPR-A (i.e., the northwest corner of subarea 230 and the far southwest corner of subarea 130 through which a lower section of the Utukok River flows). Oil and gas activity in this area has the potential to disturb subsistence use by Point Lay and Wainwright subsistence users who travel, hunt, or fish along the Kokolik, Utukok, and upper Ivisaru rivers. Setbacks along rivers would mitigate potential impacts. The subsistence analysis concludes that the other protections provided to these communities under Alternative B-1 (namely making major coastal waterbodies unavailable for leasing) outweigh any potential disruption from this area.

Under Alternative B-1, the greatest difference regarding impacts to subsistence use compared to Alternative A would be the prohibitions of both leasing and the construction of permanent non-subsistence infrastructure in most of an enlarged Teshekpuk Lake Special Area. It is expected that impacts to terrestrial mammals and subsistence use in the vicinity of Teshekpuk Lake would be significantly reduced under Alternative B-1 compared to the no-action alternative, particularly with respect to caribou calving, insect-relief habitat, and migration corridors, given the approximately 2.7 million additional acres that would be unavailable for leasing (see sections 4.4.9.1, "Terrestrial Mammals," and 4.4.13.2, "Subsistence," "Oil and Gas Exploration and Development Activities" in Volume 2). Precluding construction of permanent facilities, such as pipelines, roads, and production pads, within the narrow caribou movement/migration corridors located both to the east and the west of Teshekpuk Lake reduces the risk of displacement of the Teshekpuk Caribou Herd and of dramatic shifts in the current use-area of the caribou.

The primary reason for making most of an enlarged Teshekpuk Lake Special Area under Alternative B-1 unavailable for leasing is to protect important habitat for caribou and birds. Making this area unavailable for leasing will reduce impacts to several species of birds that are important subsistence resources, including white-fronted geese, black brant, and king and common eiders. Protecting the habitat of brant provides greater subsistence resource security for harvesters across the North Slope, in Northwest Alaska, and in the Yukon-Kuskokwim Delta.

A.2.2.2 Evaluation of the Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act of 1976, as amended, gave the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. In 1980, Congress granted the authorization for petroleum production to occur and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Reserve.

The purpose of the NPR-A IAP/EIS is to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve while providing special protections for specific habitats and site-specific resources and uses, and to ensure that the BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Alternative B-1 would provide a comprehensive set of land management rules for the entire NPR-A. No current BLM IAP decisions are effective for the portions of the NPR-A outside of the Northeast and Northwest NPR-A planning areas. State and Native corporation lands cannot be considered in a BLM plan, and under BLM policy, no other BLM lands outside of Alaska are considered under ANILCA.

A.2.2.3 Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. Neither of these alternatives, however, would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve. Alternative B-1 reduces the use of public lands needed for subsistence purposes to a greater extent than the other alternatives.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous records of decision allowed the BLM to enter into contracts with several oil companies, by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, "Alternatives Considered but Eliminated from Detailed Analysis" in Volume 1 of this IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.2.4 Findings

Alternative B-1 would not significantly restrict subsistence use by communities in or near the NPR-A (Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright). The type of impacts that would occur from non-oil and gas activities and from oil and gas activities under Alternative B-1 would be similar to those that would occur as a result of Alternative A but would be reduced in intensity and duration. Furthermore, adequate stipulations and best management practices have been incorporated in Alternative B-1—including specific procedures for subsistence consultation with directly affected subsistence communities, requirements for extensive studies of caribou movement, and increased setbacks or other protective measures specific to birds—to ensure that significant restrictions to subsistence uses and needs would not occur.

A.2.3 Evaluation and Findings for Alternative B-2

Alternative B-2, including its stipulations and best management practices, emphasizes the protection of surface resources while making nearly 11.8 million acres of federally owned subsurface (52 percent of the total in NPR-A) available for oil and gas leasing. It would enlarge two Special Areas and create one new Special Area. Alternative B-2 would prohibit leasing on approximately 3.1 million acres (85 percent) of an enlarged Teshekpuk Lake Special Area, protecting critical habitat for geese and the Teshekpuk Lake Caribou Herd. Alternative B-2 would prohibit leasing and new non-subsistence infrastructure in all but the northernmost section of the Utukok River Uplands Special Area. Major coastal waterbodies would be unavailable for leasing.

A.2.3.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

The analysis of Alternative B-2 on subsistence uses is presented in section 4.5.13, "Alternative B-2, Subsistence" in Volume 3. This analysis considers the effects of non-oil and gas activities, the effects of oil and gas activities, the effects of oil spills, and the effectiveness of the associated stipulations and best management practices as presented by BLM. The analysis concludes that the effect of Alternative B-2 on subsistence uses and needs would be less than that of Alternative A. Effects would remain localized and would not significantly affect subsistence species, access to subsistence species, or subsistence use by the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, or Wainwright.

At issue in this evaluation are the differences between Alternative A and Alternative B-2. The smaller amount of oil and gas development projected for Alternative B-2 compared to Alternative A would likely result in fewer disturbances to subsistence resources, although there are subtle differences among North Slope communities concerning how oil and gas development under Alternative B-2 would impact subsistence uses. Alternative B-2 primarily differs from the no-action alternative in the following regards:

- By making unavailable for leasing and restricting non-subsistence development in coastal waterbodies and in much of a greatly enlarged Teshekpuk Lake Special Area, Alternative B-2 provides significantly more security for key subsistence species and use areas than Alternative A. Making much of the Teshekpuk Lake Special Area unavailable for leasing reduces the risk of direct and indirect impacts to subsistence harvests of Teshekpuk Caribou Herd in Nuiqsut, Barrow, Atqasuk, and Anaktuvuk Pass.

- Alternative B-2 provides greater setbacks from numerous rivers that are important for subsistence use.
- Alternative B-2 would make the upper portion of the Kasegaluk Lagoon unavailable for leasing.
- Alternative B-2 provides for a 107,000-acre Peard Bay Special Area and would make Peard Bay unavailable for leasing. This provides more protection to subsistence use areas for the communities of Wainwright, Barrow, and Atqasuk.
- Coastal waterbodies, including Admiralty Bay, Dease Inlet, and Elson Lagoon that are important for Barrow and, to a lesser extent, for Atqasuk would be unavailable for leasing under Alternative B-2.
- The area surrounding the lower sections of both the Chipp and Ikpikpuk rivers and much of the lower section of the Topagaruk River, important to subsistence users from Barrow, would be unavailable for leasing under Alternative B-2.
- Under Alternative B-2, Nuiqsut's subsistence use area would be better protected because Fish Creek, all of the Teshekpuk Caribou Herd's core calving and insect relief area, important waterfowl habitat in the Teshekpuk Lake area, and the Kogru River would be unavailable for leasing. The most critical area surrounding Teshekpuk Lake itself would be protected from any new non-subsistence infrastructure.
- Alternative B-2 extends the coastal setback to 1 mile inland, instead of three-quarters of a mile, in order to protect molting geese habitat as well as summer shoreline habitat for polar bears, walrus, and seals. Alternative B-2 also extends this coastal protection zone along the entire coast of the NPR-A.
- Unlike Alternative A, Alternative B-2 includes a provision (best management practice H-3) that minimizes impacts to important subsistence species by prohibiting employees of the oil and gas industry or other permitted activities to hunt or trap while working. This measure addresses a key concern of subsistence hunters, which is the encroachment of and competition for resources posed by outside hunters.
- Unlike Alternative A, Alternative B-2 makes available the northwest corner of southern NPR-A (i.e., the northwest corner of subarea 230 and the far southwest corner of subarea 130 through which a lower section of the Utukok River flows). Oil and gas activity in this area has the potential to disturb subsistence use by Point Lay and Wainwright subsistence users who travel, hunt, or fish along the Kokolik, Utukok, and upper Ivisaru rivers. Setbacks along rivers would mitigate potential impacts. The subsistence analysis concludes that the other protections provided to these communities under Alternative B-2 (no leasing in major coastal waterbodies and no leasing or new non-subsistence infrastructure in all but the northernmost section of the Utukok River Uplands Special Area) outweigh any potential disruption from this area.
- In areas closed to leasing but where new non-subsistence infrastructure would not be prohibited (such as pipelines), several stipulations provide extra protections relevant to that infrastructure.

Under Alternative B-2, the greatest difference regarding impacts to subsistence use would be making most of an enlarged Teshekpuk Lake Special Area unavailable for leasing and the prohibition of leasing and permanent non-subsistence infrastructure in the 27 percent of the Teshekpuk Lake Special Area that is most critical for subsistence resources. It is expected that impacts to terrestrial mammals and subsistence use in the vicinity of Teshekpuk Lake would be reduced under Alternative B-2 compared to the no-action alternative, particularly with respect to caribou calving, insect-relief habitat, and migration corridors (see sections 4.5.9.1, "Terrestrial Mammals," and 4.5.13.2, "Subsistence, Oil and Gas Exploration and Development Activities" in Volume 3). Precluding construction of permanent facilities, such as pipelines, roads, and production pads, within the narrow caribou movement/migration corridors located both to the east and the west of Teshekpuk Lake reduces the risk of displacement of the Teshekpuk Caribou Herd and of dramatic shifts in the current use-area of the caribou.

The primary reason for making most of an enlarged Teshekpuk Lake Special Area under Alternative B-2 unavailable for leasing is to protect important habitat for caribou and birds. Making this area unavailable for leasing will reduce impacts to several species of birds that are important subsistence resources, including white-fronted geese, black brant, and king and common eiders. Protecting the habitat of brant provides greater subsistence resource security for harvesters across the North Slope, in Northwest Alaska, and in the Yukon-Kuskokwim Delta.

A.2.3.2 Evaluation of the Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act of 1976, as amended, gave the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. In 1980, Congress granted the authorization for petroleum production to occur and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Reserve.

The purpose of the NPR-A IAP/EIS is to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve while providing special protections for specific habitats and site-specific resources and uses, and to ensure that the BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Alternative B-2 would provide a comprehensive set of land management rules for the entire NPR-A. No current BLM IAP decisions are effective for the portions of the NPR-A outside of the Northeast and Northwest NPR-A planning areas. State and Native corporation lands cannot be considered in a BLM plan, and under BLM policy, no other BLM lands outside of Alaska are considered under ANILCA.

A.2.3.3 Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. Neither of these alternatives, however, would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve. Alternative B-2 reduces the use of public lands needed for subsistence purposes to a greater extent than all other alternatives except for Alternative B-1.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous records of decision allowed the BLM to enter into contracts with several oil companies, by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, "Alternatives Considered but Eliminated from Detailed Analysis" in Volume 1 of this IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.3.4 Findings

Alternative B-2 would not significantly restrict subsistence use by communities in or near the NPR-A (Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright). The type of impacts that would occur from non-oil and gas activities and from oil and gas activities under Alternative B-2 would be similar to those that would occur as a result of Alternative A, but would be reduced in intensity and duration. Furthermore, adequate stipulations and best management practices have been incorporated in Alternative B-2—including specific procedures for subsistence consultation with directly affected subsistence communities, requirements for extensive studies of caribou movement, and increased setbacks or other protective measures specific to birds—to ensure that significant restrictions to subsistence uses and needs would not occur.

A.2.4 Evaluation and Findings for Alternative C

Under Alternative C of the NPR-A IAP/EIS, 17.9 million acres (more than three-quarters) of the Petroleum Reserve would be available for oil and gas leasing. Several coastal waterbodies and approximately 4.4 million acres in the far south of the Petroleum Reserve would not be available for oil and gas leasing. Alternative C includes several protective measures that would provide more protection of subsistence use areas than does Alternative A.

A.2.4.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

The analysis of the effects of Alternative C on subsistence uses, presented in section 4.6.13 ("Alternative C, Subsistence" in Volume 3) considers the effects of non-oil and gas activities, oil and gas activities, and oil spills, and the effectiveness of the stipulations and best management practices required by the BLM. The analysis concludes that Alternative C would not significantly affect primary subsistence use species, access to subsistence resources, or subsistence use by the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright. Although, overall, more land within the NPR-A is made available for oil and gas leasing under Alternative C than under Alternative A, the impact of Alternative C on subsistence uses will be less than the impact to subsistence uses under Alternative A, because Alternative C would not allow leasing in several key coastal waterbodies and includes stricter regulations in areas of the Teshekpuk Lake Special Area that would make a larger area unreachable for oil and gas activities. Impacts that would occur under Alternative C are expected to be localized, of short duration, and not significant at the population level for most species.

At issue in this evaluation are the differences between Alternative A and Alternative C. The greater gas development projected for Alternative C compared to Alternative A could result in more acreage being disturbed by development (e.g., approximately 24 percent more acres could be surveyed by seismic under Alternative C than under Alternative A). However, natural gas pipelines, unlike oil pipelines, would be buried and are therefore far less disruptive to subsistence hunters. There are several differences among North Slope communities on how oil and gas development under Alternative C would impact subsistence uses. Alternative C primarily differs from the no-action alternative in the following regards:

- Wainwright's nearby coastal waterbodies (Peard Bay, the Kasegaluk Lagoon, Wainwright Inlet, and the lower section of the Kuk River) would be unavailable for leasing under Alternative C. The preclusion of leasing in that portion of the Kasegaluk Lagoon that is within the NPR-A would result in less impacts to subsistence users from Point Lay.
- Alternative C provides for a 107,000-acre Peard Bay Special Area to protect haul-out areas and nearshore waters for marine mammals, and migration and staging habitat for shorebirds and waterbirds, which as a result, provides extra protections from oil and gas activity in a subsistence area important to both Wainwright and Barrow.
- Although Alternative C provides strong protective measures to reduce impacts on resources from oil and gas activities and thus protects much of the Utukok River Uplands Special Area, the entire southern NPR-A is unavailable for leasing under Alternative A, which, therefore, provides stronger protection for a larger subsistence area south of Wainwright/east of Point Lay. Overall, the preclusion of leasing in nearby coastal waterbodies that is provided by Alternative C would likely prevent more direct impacts to those communities' subsistence resources and use areas than the protections provided by Alternative A.
- Alternative C would protect more of Nuiqsut's subsistence use area by putting in place special restrictions on oil and gas activities around the Kogru River and by increasing the coastal area setback to 1 mile from the west side of the Colville Delta to Tangent Point. Under Alternative C, the Teshekpuk Lake Special Area and the Teshekpuk Lake Caribou Habitat Area are enlarged toward the southeast, overlapping with Nuiqsut's high caribou use area. Alternative C also expands the Teshekpuk Lake Caribou Movement Corridor by 1,500 acres over its size under Alternative A, extending the area where permanent oil and gas facilities, with the exception of pipelines, is prohibited. The restrictions on oil and gas activities in these areas would protect the priority conservation areas (calving area and most of the insect relief area) for the Teshekpuk Caribou Herd, thereby protecting a significant source of food for Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, and Wainwright.
- The amount of land around Teshekpuk Lake that would be rendered unreachable by directional drilling due to restrictions on surface facilities under Alternative C is approximately three times larger than the amount of similarly affected land under

Alternative A. Under Alternative C, the likelihood of Nuiqsut hunters shifting subsistence use areas away from their traditionally used areas around Teshekpuk Lake would be less. The risk of oil and gas activity deflecting caribou away from their normal migration paths in the Teshekpuk Lake Special Area would also be less, and subsistence hunters that depend on the Teshekpuk Caribou Herd would likely save time, energy, and money if they were not required to travel to uncharacteristically distant areas to find caribou.

- Alternative C extends the coastal strip between the Kogru River and Tangent Point to 1 mile inland, instead of three-quarters of a mile, in order to protect molting geese habitat as well as summer shoreline habitat for polar bears, walrus, and seals.
- Unlike Alternative A, Alternative C includes a provision (best management practice H-3) that minimizes impacts to important subsistence species by prohibiting employees of the oil and gas industry or other permitted activities to hunt or trap while working. This measure addresses a key concern of subsistence hunters, which is the encroachment of and competition for resources posed by outside hunters.

Subsistence activities in all NPR-A communities could be directly affected by development activities under Alternative C. Alternative C would make approximately 19 percent more acreage in the NPR-A available to oil and gas leasing than Alternative A, meaning that impacts to subsistence resources and conflicts with subsistence users could occur over a larger area. Alternative C does not provide the same level of protection for the southern NPR-A as Alternative A does, which could result in a significant increase in impacts to the communities of Point Lay and Wainwright if development occurs in their subsistence use areas. However, several small but cumulatively significant changes to borders in the Teshekpuk Lake Special Area would better secure key habitats of the Teshekpuk Caribou Herd. Alternative C also makes several critically important coastal waterbodies unavailable for leasing and provides for a Peard Bay Special Area, actions which protect subsistence access and resources and reduce the risk of oil spills in particularly sensitive environments. Alternative C does not provide the same level of protection for subsistence resources and access that is provided by Alternative B-1, but it provides a greater level than the no-action alternative. Impacts would be localized, of short duration, and not significant at the population level for most species.

A.2.4.2 Evaluation of Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act of 1976, as amended, gave the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. In 1980, Congress granted the authorization for petroleum production to occur and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Petroleum Reserve.

The purpose of the NPR-A IAP/EIS is to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses, and to ensure that the BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Alternative C would provide a comprehensive set of land management rules for the entire NPR-A. No current BLM IAP decisions are effective for the portions of the NPR-A outside of the Northeast and Northwest NPR-A planning areas. State and Native corporation lands cannot be considered in a BLM plan, and under BLM policy other BLM lands outside of Alaska are not considered under ANILCA.

A.2.4.3 Evaluation of Other Alternatives that Would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. However, neither of these alternatives would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous records of decision allowed the BLM to enter into contracts with several oil companies, by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, “Alternatives Considered but Eliminated from Detailed Analysis” in Volume 1 of this IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.4.4 Findings

This evaluation concludes that Alternative C would not significantly restrict subsistence use by communities in or near the NPR-A (Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright). The type of impacts that would occur from non-oil and gas activities and from oil and gas activities under Alternative C would be similar to those that would occur as a result of Alternative A, but would be reduced in intensity and duration. Furthermore, adequate stipulations and best management practices have been incorporated in Alternative C—including specific procedures for subsistence consultation with directly affected subsistence communities, requirements for extensive studies of caribou movement, and increased setbacks or other protective measures specific to birds—to ensure that significant restrictions to subsistence uses and needs would not occur.

A.2.5 Evaluation and Findings for Alternative D

Under Alternative D of the NPR-A IAP/EIS, all land under the stewardship of the BLM within the planning area would be available for oil and gas leasing. Current deferrals would be honored until their respective expiration dates.

A.2.5.1 Evaluation of the Effect of Use, Occupancy, or Disposition on Subsistence Uses and Needs

The analysis of the effects of Alternative D on subsistence uses, presented in section 4.7.13 (“Alternative D, Subsistence” in Volume 3), considers the effects of non-oil and gas activities, oil and gas activities, and oil spills, and the effectiveness of the stipulations and best management practices required by the BLM. The analysis concludes that Alternative D may significantly affect primary subsistence species, access to subsistence resources, or subsistence use by the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay or Wainwright.

Although the types of effects of activities under Alternative D would be identical to those described for Alternative A, Alternative D makes the entire NPR-A, approximately 43 percent more than Alternative A, available for oil and gas leasing. As compared to the other alternatives, the extent, severity, and duration of effects under Alternative D would likely be greater, given that a larger area would be open for year-round occupation and development, which would include ecologically sensitive areas that would not be open under the other alternatives or would be offered greater levels of surface protection under the other alternatives. The impacts of Alternative D would therefore be greater than those of alternatives A, B-1, B-2, or C. Although many impacts would be localized, of short duration, and not significant at the population level for most species, the overall potential for numerous disturbances to critical subsistence species and for conflicts over access to subsistence areas under Alternative D support the conclusion that subsistence use may be significantly affected.

The amount of habitat loss and degradation would be greater under Alternative D than the other alternatives. The most significant changes would be (1) the availability of Teshekpuk Lake and the Teshekpuk Lake Special Area for oil and gas leasing with substantially less protection for surface resources in that area and (2) decreased protection for shorelines and coastal waterbodies. This evaluation considers the potential impacts of Alternative D on birds, fish, and caribou separately before analyzing the overall potential impacts to subsistence uses.

Birds

Under Alternative D, both winter and summer oil and gas activities could result in changes to nesting and molting habitat that affect waterfowl's use of the Petroleum Reserve. In general, Alternative D would allow more infrastructure in areas of very high value to birds than any other alternative and in this aspect would be less protective than the other alternatives and may result in increased habitat loss, disturbance, or mortality. Specific differences between Alternative D and Alternative A that are relevant for birds include:

- Unlike the other alternatives, Alternative D does not prohibit exploration activities in areas that are very important to many migratory species of waterbirds and shorebirds during critical life stages such as migration staging, molting, and breeding (i.e., Teshekpuk Lake, Dease Inlet, Admiralty Bay, Elson Lagoon and associated islands).
- Alternative D has a provision (K-4a) that is designed to minimize disturbance to molting geese habitat by mandating that roads will be designed to minimize impacts to molting geese. This measure is significantly weaker than K-4 under the other alternatives where it prohibits all permanent facilities except pipelines in goose molting habitat.
- Under Alternative D, moderate to large effects to birds could occur in the goose molting area, the entire area of which would be unavailable for oil and gas leasing under the other alternatives.

- The potential for collisions with ground and air traffic would be greater under Alternative D and, because the expected number of sealifts in Alternative D would be higher than in the other alternatives, the impacts from bird collisions with barges would also be higher in Alternative D. Minor effects to individual birds (not populations) are expected to occur from all types of collisions combined.
- Under Alternative D, there would be greater potential for bird mortality due to predation than under any of the other alternatives as there would be more human activity and anthropogenic sources of food available. More nesting and denning sites and hunting perches would be available for predators.
- Birds found in marine habitats (including subsistence species king and common eiders, greater white fronted, Canada and snow geese) within the NPR-A could be particularly susceptible to the negative impacts of an oil spill. The greater need for marine transportation under Alternative D relative to all other alternatives would increase the opportunity for a spill to occur.
- Alternative D could result in the greatest amount of permanent and temporary bird habitat loss. Gravel mining and placement for the construction of oil and gas field infrastructure would have the greatest potential to result in the permanent loss of bird habitat. Temporary loss of tundra habitat adjacent to gravel roads and pads could occur as a result of thermokarst, dust deposition, snow accumulation, water withdrawals (if recharge does not occur), and impoundment formation.

Fish

Alternative D could result in an increased likelihood that fish and fish habitats could be affected by development activities that could potentially reduce fish populations, divert fish from their normal locations, or contaminate fish populations and habitat. Specific differences between Alternative D and the other alternatives that are relevant for fish include:

- Alternative D has no comparable provisions that would provide additional protection to the Kogru River, Dease Inlet, Admiralty Bay, Elson Lagoon, Peard Bay, Wainwright Inlet/Kuk River, and Kasegaluk Lagoon.
- Under Alternative D, NPR-A lands available for leasing include 34,100 miles of potential stream habitat: 92 percent more than Alternative A.
- The incidence of impacts on fish occurring from seismic surveys under Alternative D (77,562 surveying miles) would be 43 percent more than under Alternative A, 33 percent more than Alternatives B-1 and B-2, and 9 percent more than Alternative C.
- Expected incidence of impacts on fish from winter oil and gas activities under Alternative D (114,794 ice road/snow trail miles) would be 41 percent more than Alternative A, 97 percent more than Alternative B-1, 83 percenter more than Alternative B-2, and 6 percent more than Alternative C.
- The degree of foreseeable impacts on fish from year-round domestic freshwater demand under Alternative D (168 oil and gas production pads) would be 50 percent more than Alternative A, 110 percent more than Alternative B-1, 50 percent greater than Alternative B-2, and 13 percent more than Alternative C.

- The incidence of impacts on fish from roads and pipelines and associated activities under Alternative D would be 73 percent more than Alternative A, 108 percent more than Alternative B-1, 91 percent more than Alternative B-2, and 3 percent more than Alternative C.
- The incidence of impacts on fish related to gravel pads and airstrips under Alternative D (239 gravel pads and airstrips) would be 48 percent more than Alternative A, 102 percent more than Alternative B-1, 89 percent more than Alternative B-2, and 8 percent more than Alternative C.

Caribou

In general, Alternative D would have a higher probability of causing a population-level effect to one or both of the Teshekpuk Caribou Herd and Western Arctic Herd. Impacts to caribou from roads and pipelines; motor vehicle, aircraft, and foot traffic; and habitat alteration associated with gravel mining and construction would be greater under Alternative D than under other alternatives, given the larger development scenario. Disturbance could directly affect about 60 percent more acres of habitat under long-term disturbance as compared to Alternative A. Functional loss of habitat would be greater than the actual development footprint. Wolfe (2000) suggested that when caribou in the Central Arctic Herd avoided areas within 2.5 miles of roads and pipelines, the functional habitat loss increased from 2 percent (the immediate footprint of roads and gravel pads) to 29 percent.

If a field were developed in the area surrounding Teshekpuk Lake, production pads, pipelines, within-field roads, and other facilities would be located within areas used by the Teshekpuk Caribou Herd for calving, insect relief, and wintering. A field development in the northern section of the NPR-A would also require a connector pipeline to link the oil field with facilities to the east, further affecting the Teshekpuk Lake area and possibly impeding movements until the Teshekpuk Caribou Herd habituates to its presence (Person et al. 2007). Post-parturient caribou and calves could be deflected or diverted from preferred habitats in the vicinity of Teshekpuk Lake if development were to occur in that area (Murphy and Lawhead 2000).

Unlike the other alternatives, Alternative D has no provision to protect the Teshekpuk Lake Southern Caribou Calving Area and Alternative D has the highest probability of resulting in development within the calving grounds of the Teshekpuk Caribou Herd. Therefore, Teshekpuk Herd caribou could be exposed to oil and gas development facilities and activities at a time of year when they are most sensitive to disturbance. Wilson et al. (2011) showed that significant portions of high quality calving habitat could be lost to the Teshekpuk Caribou Herd as a result of development. This suggests that if Teshekpuk Caribou Herd females are displaced from part or all of the current calving area, parturient females would be unlikely to find similar areas elsewhere across their range. This situation could result in reduced calving success and negatively affect the Teshekpuk Caribou Herd at the population level.

Unlike the other alternatives, Alternative D has no provision to protect Teshekpuk Lake Caribou Movement Corridors. Migrating caribou could be delayed or deflected by aircraft traffic and other human activity during development and construction. As discussed in section 3.4.3, “Subsistence” in Volume 1, Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, and Wainwright depend on the Teshekpuk Caribou Herd as a subsistence species. Even a temporary disruption of these communities' harvest patterns would have negative effects for subsistence users.

Climate change could make foraging more difficult on herbivores during winter, possibly causing negative, synergistic effects to mammals when combined with disturbance and displacement of mammals by oil and gas activities.

Subsistence

The increased activity that could occur over a wider area under Alternative D could inhibit subsistence users from harvesting in their traditional use areas to a greater degree than all other alternatives. The avoidance of traditionally used subsistence areas due to development and aircraft use would likely be accompanied by anxiety over this loss and by reduced subsistence harvests. Oil infrastructure on the east side of the Colville River has resulted in the nonuse of this area by the residents of Nuiqsut who do not feel comfortable hunting near or around oil developments. Hunters could avoid the development if enough economically recoverable oil and/or gas were discovered to warrant additional development in the traditional subsistence use areas of Atqasuk, Barrow, Nuiqsut, Point Lay, or Wainwright. The result would be an overall reduction in lands used for subsistence purposes.

The deflection of caribou and other important subsistence resources from areas of activity would result in increased difficulty harvesting caribou and other subsistence resources and the necessity to make longer and more distant trips in order to have a successful harvest. These factors would increase the cost, risk, and time commitment subsistence harvesting entails. Decreased opportunities to harvest terrestrial mammals could be especially problematic if climate change inhibits fall travel by delaying freeze up or causes subsistence species to shift their migration routes or schedules. If climate change causes Arctic Ocean ice to retreat farther from the shore, it will make the harvesting of whales and other marine mammals more difficult, which could in turn increase pressure to harvest terrestrial subsistence foods. Specific differences between Alternative D and Alternative A that are particularly relevant for subsistence uses include:

- Alternative D has no provision that would protect fish and wildlife habitat, subsistence cabins, and subsistence activities by prohibiting permanent oil and gas facilities on the shores of Teshekpuk Lake, Dease Inlet, Admiralty Bay and Elson Lagoon.
- Alternative D has no provision comparable to K-8, which protects subsistence resources and traditional access in the Kasegaluk Lagoon Special Area.
- Alternative D does not provide the same level of protection for the southern NPR-A as Alternative A does, which could result in impacts to the communities of Point Lay and Wainwright if development occurs in their subsistence use areas. The lower level of protection for the Western Arctic Herd under Alternative D, particularly the potential for development near the calving grounds of the Western Arctic Herd, decreases the food security of the over 40 Alaskan communities thatharvest those animals.
- Unlike Alternative A, Alternative D includes a provision (best management practice H-3) that minimizes impacts to important subsistence species by prohibiting employees of the oil and gas industry or other permitted activities to hunt or trap

while working. This measure addresses a key concern of subsistence hunters, which is the encroachment of and competition for resources posed by outside hunters.

Alternative D has the greatest potential to impact subsistence use of all the alternatives. The proposed stipulations and best management practices can effectively mitigate most potential impacts resulting from oil and gas activity. However, if the optimistic levels of development predicted for Alternative D occur, the amount of disturbance to subsistence uses NPR-A-wide would be significant.

A.2.5.2 Evaluation of the Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act of 1976, as amended, gave the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. In 1980, Congress granted the authorization for petroleum production to occur and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Petroleum Reserve.

The purpose of the NPR-A IAP/EIS is to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses, and to ensure that the BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Alternative D would provide a comprehensive set of land management rules for the entire NPR-A. No current BLM IAP decisions are effective for the portions of the NPR-A outside of the Northeast and Northwest NPR-A planning areas. State and Native corporation lands cannot be considered in a BLM plan, and under BLM policy other BLM lands outside of Alaska are not considered under ANILCA.

A.2.5.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. However, neither of these alternatives would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous records of decision allowed the BLM to enter into contracts with several oil companies, by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, "Alternatives Considered but Eliminated from Detailed Analysis" in Volume 1 of the IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.5.4 Findings

This evaluation concludes that the action may result in significant restriction to subsistence use for the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright due to the potential for widespread development in the NPR-A and the likelihood of development in particularly sensitive areas that can be expected to result in a substantial reduction in the opportunity to continue subsistence uses of renewable resources caused by a major redistribution of resources and/or extensive interference with access. Most separate impacts to subsistence resources would likely be minimal. However, displacement of the Teshekpuk Lake Herd could occur and this impact would be significant. Most importantly, Alternative D could result in a scenario where a multitude of minor impacts to subsistence species and minor disturbances to access to subsistence areas could occur in many locations within the NPR-A. If this occurred, the overall impact to the subsistence system as a result of widespread disturbance would likely be substantial.

A.2.6 Evaluation and Findings for the Cumulative Case

The goal of the cumulative analysis is to evaluate the incremental impact of the current action in conjunction with all past, present, and reasonably foreseeable future actions in or near the planning area. The cumulative analysis considers in greatest detail activities that are more certain to happen, and activities that were identified as being of great concern during scoping. Oil and gas activities considered in the analysis include past development and production, present development, and reasonably foreseeable future development. Activities not associated with oil and gas are also considered. All reasonably foreseeable future activities that may contribute to cumulative effects are considered in this analysis.

Actions included in the cumulative analysis include, but are not limited to the following:

- Road and pipeline between Umiat Area and Dalton Highway
- Chukchi Sea development
- Beaufort Seas development
- A corridor to the Ambler mining district
- Commercial gas pipeline
- Conventional oil and gas development in the Colville-Canning Area
- Unconventional oil and gas development in the Colville-Canning Area
- Spills and gas releases
- Contribution of IAP/EIS alternatives to cumulative effects

Moreover, these actions are considered in light of the shifting environmental conditions presented by climate change.

A.2.6.1 Evaluation of the Effect of Such Use, Occupancy, or Disposition on Subsistence Uses and Needs

Section 4.8, “Cumulative Effects” in Volume 4 of the IAP/EIS contains a detailed description of the cumulative-case scenario, including past effects, present effects, and the future possible oil field and infrastructure development upon which this evaluation is based. This assessment and finding assumes that all future development in the NPR-A would be subject to the stipulations and best management practices or required operating procedures incorporated into the alternatives analyzed in the IAP/EIS. The cumulative analysis expands the area of potential impact beyond the planning area to include areas in which activities could occur that would impact subsistence users of NPR-A and the subsistence resources that rely upon NPR-A habitat. Additionally, the impacts to subsistence use of migratory species, such as waterfowl, are also discussed.

The extent of expected cumulative effects on subsistence resources and subsistence access and other activities would vary depending on the alternative selected under this IAP/EIS. The analysis of the effects of the cumulative case on subsistence presented in section 4.8.7.13, “Cumulative Effects: Subsistence” in Volume 4 indicates that, irrespective of the alternative selected, cumulative activity on the North Slope has the potential to significantly restrict subsistence use for the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright. Subsistence resources also have the potential to be impacted under the cumulative case.

Cumulative effects on caribou distribution and abundance are likely to be long-term, lasting as long as the life of the oil fields. Any reduction in the calving and summer habitat use by cows and calves from future onshore leasing would represent a functional loss of habitat that could result in long-term effects on the caribou herds’ productivity and abundance.

The effects of oil and gas activities in the NPR-A would be greatest on those herds that use the Reserve, specifically the Teshekpuk Caribou Herd and Western Arctic Herd. Currently, the Teshekpuk Caribou Herd is the primary source of caribou for the communities of Atqasuk, Barrow, Nuiqsut, Wainwright, and possibly Anaktuvuk Pass. Any substantial decrease in the population numbers of this herd would have a substantial impact on all five communities. If the decrease occurred during times of unsuccessful bowhead whaling, the effects would be devastating for Atqasuk, Barrow, Nuiqsut, and Wainwright. The additional development pressure envisioned by the cumulative-case scenario could exacerbate changes in abundance and productivity of caribou, and these changes could, in turn, adversely affect subsistence harvests.

Foreseeable development with the potential to affect the NPR-A includes an all-season industrial gravel road to connect Umiat in southeast NPR-A with the Dalton Highway. The Corps of Engineers is currently the lead agency on an EIS for the proposal and is considering several alternative routes. Unless a route is selected where public access is restricted, there are likely to be important effects on subsistence resources by non-oil and gas use of the road, which could cut across north-south migration paths and potentially affect animals in the Teshekpuk Caribou Herd and Central Arctic Herd during some autumn and spring migration. Depending on the route selected, the road could provide increased access to caribou by non-local hunters and, if hunting were not appropriately managed, this could result in a cumulative increase in caribou mortality. Also, caribou may adapt to the presence of a road in a way that does not substantially affect the herds, but may have a substantial effect on subsistence hunters that rely on specific paths of movement by migrating caribou. The Umiat road and pipeline would also increase the likelihood of additional impacts to fish to the east of the NPR-A and within the NPR-A because permanent infrastructure (e.g., roads, pads, pipelines, and causeways) and gravel mining are likely to continue contributing to changes in natural drainage patterns and water quality, alternations to physical habitat, barriers to fish movement, and increased water pollution. The road could also lead to synergistic pressures on fish in the Colville

River and its tributaries due to greater use of the area for sport and subsistence fishing. Widespread opposition to the road in the North Slope Borough is based on the belief that it would effectively preclude a viable subsistence lifestyle in Anaktuvuk Pass and that it would encourage further development along an east-west line that will bifurcate the Arctic Slope, creating impacts to subsistence uses in other NPR-A communities.

Foreseeable development in the NPR-A could include onshore facilities on the Chukchi Sea coast and could extend across the entirety of the NPR-A via a pipeline that would tie into Trans-Alaska Pipeline System. Foreseeable development in the Beaufort Sea would require onshore pipelines and could require onshore processing facilities in the northeastern NPR-A that would impact Teshekpuk Caribou Herd caribou. The support infrastructure for offshore activities could make it economically profitable to extract oil and gas reserves from areas within the NPR-A which would otherwise not be economically recoverable, causing a synergistic increase in disturbance sources within the NPR-A. In this scenario, the NPR-A could, to some degree, be divided by one or two strips of industrial development. There is the potential for this scenario to have a significant impact on subsistence resources and access to those resources. Furthermore, infrastructure built for coastal onshore oil and gas activities could also encourage offshore development, creating a self-reinforcing system.

Offshore oil activity in the Chukchi and Beaufort seas could cause whales to change their travel routes, which would make subsistence whaling more dangerous and less successful. A significant reduction in bowhead whaling would have serious negative impacts on Iñupiaq communities, which are socially organized around whaling crews and whaling celebrations. The offshore development and transport that is possible under the cumulative case increases the risk of oil spills in the marine environment. Any oil spill that tainted, or was perceived to taint, whales or other marine mammals of importance to subsistence users would have a significant negative effect on those users. If such a spill affected migration patterns or distributions of any marine mammal used for subsistence, it would also have significant negative effect on subsistence users.

Areas east of Point Lay, south and east of Wainwright, and surrounding Atqasuk could experience development of natural gas. Development is in the planning stages for the Colville River Delta north of Nuiqsut to an area southwest of the village, which would effectively encircle the community, making it necessary for subsistence hunters traveling in nearly every direction to pass through some kind of development on the way to traditional subsistence harvest areas. Because Iñupiaq hunters are reluctant to use firearms near oil production facilities and pipelines, there would be a perceived barrier to harvest in these areas. Subsistence users currently avoid the Kuparuk and Meltwater areas because of the physical barriers pipelines and elevated gravel roads pose to winter snowmachine travel, and have expressed concerns about hunting close to oil production and processing facilities because of perceived regulatory barriers (ENSR 2004, Nukapigak 2012). Additionally, many community members fear contamination of their subsistence resources by oil production facilities.

Effects on subsistence harvest patterns from natural gas development and production could occur from natural gas blowouts, noise and traffic disturbance, and construction activities under any of the alternatives. Subsistence hunters, who already tend to avoid oil field infrastructure, may be even more likely to avoid aboveground gas pipelines for fear of a blowout. Noise and disturbance activities due to the development of a gas field, especially to caribou, would be local (within 3 to 4 km of the pipeline corridor) but would persist for the life of the field. A much greater impact from a gas pipeline would be effects from additional gas development that a pipeline would make possible (already analyzed under the five alternatives) within and to the east and west of NPR-A. Commercial gas production on the North Slope would likely result in more infrastructure in the foothills area and in the subsistence use areas of Point Lay, Atqasuk, and Wainwright, thus increasing the area that subsistence users are likely to avoid and the habitat for subsistence species that may be impacted. Permanent facilities will likely compel subsistence hunters to travel further to harvest game at a greater cost in terms of time, fuel, wear and tear on equipment and people, and lost wages.

For analysis purposes, the IAP/EIS assumes that the North Slope Borough population would fluctuate over time reflecting oil and gas production rates. If onshore and offshore oil and gas production in the North Slope increases as predicted, the population will grow at a rate of approximately 2 percent per year until the end of the century. The effects of such growth on competition for subsistence resources are difficult to predict, but it is possible that over time there would be increased competition among local subsistence users.

The effects of global climate change on marine mammals are unclear, but may result in more ship traffic in the Beaufort over a longer ice-free season, commercial fisheries in the Chukchi and Beaufort, and displacement and distributional changes, if not population changes, among marine mammals. Climate change is likely to have the greatest influence on marine mammal populations in and adjacent to the planning area; however, species' resilience as well as feedback and interactions remain highly uncertain. Estimating the incremental addition of direct human activities (disturbance, hunting and habitat alteration) remains speculative, but climate change by itself is likely to have significant effects on the marine mammal community of the Beaufort and Chukchi Seas. The reduction of sea ice has exacerbated coastal erosion, weather has become less predictable, the shore ice in spring is less stable for whaling, fall travel for caribou is hampered by a late and unreliable freeze up, ice cellars provide less reliable food storage, and the number of marine mammals that are experiencing habitat loss is apparent. If permafrost loss increases as predicted, there could be synergistic cumulative effects on infrastructure, travel, landforms, sea ice, river navigability, habitat, availability of fresh water, and availability of terrestrial mammals, marine mammals, waterfowl and fish, all of which could necessitate relocating communities or their population, shifting the population to places with better subsistence hunting and causing a loss or dispersal of community residents (National Research Council 2003, Arctic Climate Impact Assessment 2004).

A.2.6.2 Evaluation of the Availability of Other Lands for Oil and Gas Exploration and Development

The Naval Petroleum Reserves Production Act, as amended, gives the Secretary of the Interior the authority to conduct oil and gas leasing in the NPR-A. However, the law prohibited petroleum production from occurring in the NPR-A until authorized by Congress. In 1980, Congress granted that authorization and directed the Secretary of the Interior to undertake a program of competitive leasing of potential oil and gas tracts in the Reserve. The BLM is undertaking this NPR-A IAP/EIS to fulfill the BLM's responsibilities to manage these lands under authority of the Naval Petroleum Reserves Production Act and Federal Land Policy and Management Act and to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses, and to ensure that BLM's land management will provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System. Other lands managed by the BLM are either too remote for economically viable oil and gas production, or have a low probability of containing sufficient quantities of oil or gas. State and Native corporation lands cannot be considered in a BLM plan, and other BLM lands outside of Alaska are not considered under the ANILCA as per BLM Policy.

A.2.6.3 Evaluation of Other Alternatives that would Reduce or Eliminate the Use, Occupancy, or Disposition of Public Lands Needed for Subsistence Purposes

Alternatives that would reduce or eliminate the use of public lands needed for subsistence purposes include: (1) making more land in the NPR-A unavailable for oil and gas leasing than is considered in this IAP/EIS, or (2) not allowing oil and gas activity to occur. However, neither of these alternatives would satisfy the underlying purposes of the IAP/EIS to continue a program of competitive leasing of potential oil and gas tracts in the NPR-A and to establish consistent oil and gas leasing stipulations and best management practices across the entire Reserve.

The Secretary of the Interior has directed the BLM to determine the appropriate management of all BLM-managed lands in NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction. Additionally, previous RODs allowed the BLM to enter into contracts with several oil companies, by leasing land for oil and gas exploration. Many of these leases are still in effect. Section 2.4, "Alternatives Considered but Eliminated from Detailed Analysis" in Volume 1 of the IAP/EIS discusses other alternatives that were considered, but eliminated from detailed analysis.

A.2.6.4 Findings

The cumulative case as presented in this analysis, when taken in conjunction with all alternatives, would result in a reasonably foreseeable and significant restriction of subsistence use for the communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright, due to a decrease in resource abundance, significant alteration in the distribution of resources, and a significant restriction on the access of subsistence users. This finding requires a positive determination pursuant to ANILCA § 810.

The distribution of caribou populations on the North Slope has been affected by Prudhoe Bay development, and access to subsistence resources has been compromised there. Although procedures will be in place to ensure that future development affects access as little as possible, it is still probable the total area available for subsistence purposes will be reduced. If a major marine oil spill were to occur in the future, it could significantly affect both populations and distributions of fish, and whales and other marine animals, causing significant restrictions to subsistence use of these resources. Oil and gas infrastructure located in core caribou calving or insect-relief areas would result in the displacement, and possible reduction, of the herd. Population growth may result in a greater number of residents relying on local resources to meet their needs. These restrictions have the potential to affect Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright.

A.3 Notice and Hearings

ANILCA § 810(a) provides that no "withdrawal, reservation, lease, permit, or other use, occupancy or disposition of the public lands which would significantly restrict subsistence uses shall be effected" until the federal agency gives the required notice and holds a hearing in accordance with ANILCA § 810(a)(1) and (2). The BLM will provide notice in the Federal Register that it made positive findings pursuant to ANILCA § 810 that Alternative D and the cumulative case presented in the NPR-A IAP/EIS, when taken in conjunction with all alternatives, met the "may significantly restrict" threshold. As a result, public hearings were held in the potentially affected communities of Anaktuvuk Pass, Atqasuk, Barrow, Nuiqsut, Point Lay, and Wainwright. Notice of these hearings was provided in the Federal Register and by way of the local media, including the Arctic Sounder newspaper, and KBRW, the local Barrow radio station with coverage to all villages on the North Slope.

A.4 Subsistence Determinations Under ANILCA § 810(a)(3)(A), (B), and (C)

ANILCA § 810(a) provides that no "withdrawal, reservation, lease, permit, or other use, occupancy or disposition of the public lands which would significantly restrict subsistence uses shall be effected" until the federal agency gives the required notice and holds a hearing in accordance with ANILCA §810(a)(1) and (2), and makes the three determinations required by ANILCA § 810(a)(3)(A), (B), and (C). The three determinations that must be made are: (1) that such a significant restriction of subsistence use is necessary, consistent with sound management principles for the utilization of the public lands; (2) that the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other such disposition; and (3) that reasonable steps will be taken to minimize adverse impacts to subsistence uses and resources resulting from such actions [16 U.S.C. § 3120(a)(3)(A), (B), and (C)].

The BLM has found in this subsistence evaluation that Alternative D and the cumulative case considered in this IAP/EIS for all alternatives would significantly restrict subsistence uses. Therefore, the BLM has undertaken the notice and hearing procedures required by ANILCA § 810 (a)(1) and (2) in conjunction with release of the Draft NPR-A IAP/EIS in order to solicit public comment from the potentially affected communities and subsistence users.

The determinations below satisfy the requirements of ANILCA § 810(a)(3)(A), (B), and (C).

A.4.1 Significant Restriction of Subsistence Use is Necessary, Consistent with Sound Management Principles for the Utilization of Public Lands

BLM is undertaking this NPR-A IAP/EIS to fulfill BLM's responsibilities to manage these lands under authority of the Naval Petroleum Reserves Production Act and Federal Land Policy and Management Act and to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses. In addition, the IAP/EIS will provide the opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska

Pipeline System or a future gas pipeline from the North Slope. The Naval Petroleum Reserves Production Act authorizes and directs the Secretary of the Interior to “further explore, develop and operate” the National Petroleum Reserve-Alaska (10 U.S.C. § 7421). At the same time, the statute also requires that all oil and gas activities “undertaken pursuant to this section shall include or provide for such conditions, restrictions, and prohibitions as the Secretary deems necessary or appropriate to mitigate reasonably foreseeable and significantly adverse effects on the surface resources” of the National Petroleum Reserve – Alaska (42 U.S.C. § 6508).

It was in furtherance of these objectives, together with other management guidance found in the Naval Petroleum Reserves Production Act, Federal Land Policy and Management Act, NEPA, and ANILCA that this IAP/EIS was undertaken. After considering a broad range of alternatives, Alternative B-2 was developed to fulfill the purpose and need of this planning effort, while incorporating protective measures that serve to minimize impacts to important subsistence resources and subsistence-use areas. Alternative B-2 considers the necessity for economically feasible development while providing effective protections to minimize any impacts on subsistence resources and uses. Under Alternative B-2, the lease stipulations and best management practices that accompany the alternative serve as the primary mitigation measures to be used to reduce the impact of the proposed activity on subsistence uses and resources.

The BLM has considered and balanced a variety of factors with regard to the proposed activity on public lands, including, most prominently, the comments received during the public meetings and hearings which stressed the importance of protecting essential caribou movement/migration corridors for both the Teshekpuk Lake and Western Arctic caribou herds. The BLM has determined that the significant restriction that may occur under Alternative B-2, when considered together with all the possible impacts of the cumulative case, is necessary, consistent with sound management principles for the use of these public lands, and for BLM to fulfill the management goals for the Planning Area as guided by the statutory directives in the Naval Petroleum Reserves Production Act, Federal Land Policy and Management Act, and other applicable laws.

A.4.2 The Proposed Activity will Involve the Minimal Amount of Public Lands Necessary to Accomplish the Purposes of such Use, Occupancy or Other Disposition

The BLM has determined that Alternative B-2 involves the minimal amount of public lands necessary to accomplish the purposes of the planning effort—namely, to consider consistent oil and gas leasing stipulations and best management practices across the entire Petroleum Reserve, while providing special protections for specific habitats and site-specific resources and uses, and allowing the opportunity for necessary infrastructure to support oil and gas exploration and development. Alternatives that varied between opening no additional lands, less additional lands, some additional lands, or all lands to leasing were analyzed. Alternative B-2, including its stipulations and best management practices, emphasizes the protection of surface resources while making nearly 11.8 million acres of federally owned subsurface (52 percent of the total in NPR-A) available for oil and gas leasing. Alternative B-2 would make approximately 11 million acres of the NPR-A unavailable for oil and gas leasing. It would enlarge two Special Areas and create one new Special Area. Alternative B-2 makes unavailable for leasing approximately 3.1 million acres of an enlarged Teshekpuk Lake Special Area, protecting critical habitat for geese and the Teshekpuk Lake Caribou

Herd. Approximately 7.3 million acres in southwestern NPR-A would also be unavailable; they include important calving and insect-relief habitat for the Western Arctic Caribou Herd. Major coastal waterbodies that are integral for subsistence uses and needs such as Admiralty Bay, Wainwright Inlet, Peard Bay, and Kasegaluk Lagoon are unavailable for leasing.

A.4.3 Reasonable Steps will be Taken to Minimize Adverse Impacts upon Subsistence Uses and Resources Resulting from such Actions.

When BLM began its NEPA scoping process for the current plan, it internally identified subsistence as one of the major issues to be addressed. The information found within the analysis of impacts to subsistence, including access, harvests, and traditional use patterns, as well as the results of public scoping meetings in the villages of the North Slope, meetings with the National Petroleum Reserve – Alaska Subsistence Advisory Panel, and consultation with tribal and local governments (especially the North Slope Borough, a cooperating agency), were used to craft Alternative B-2. In addition, the BLM took into consideration comments from villages and individuals of the North Slope during the ANILCA Subsistence Hearings. This information resulted in the retention and addition of several protective measures that further minimize adverse impacts to subsistence uses and resources. They include:

- Best management practice A-11 specifically addresses contaminants in subsistence foods and requires baseline data be collected prior to any development, as well as monitoring during operation through the abandonment phase. Additionally, best management practice A-12 addresses contaminant monitoring of subsistence foods should an oil spill with potential to impact human health occur within the NPR-A.
- Best management practice E-1 addresses access to subsistence resources and the protection of resource habitats by requiring that all roads must be designed, constructed, maintained, and operated to create minimal environmental impacts and to protect subsistence use and access to subsistence hunting and fishing areas. Similarly, Lease Stipulation E-3 sets the requirement for the construction of dock and causeways so as not to impede fish passage or subsistence access. Best management practice E-7 sets forth the requirements for pipelines and associated roads in order to allow the free movement of caribou and access to subsistence users.
- Best management practice F-1 addresses aircraft use by permittees in the NPR-A and sets forth altitude requirements for flying over multiple species at various times during the year, as well as BLM expectations for aircraft use near subsistence cabin and camps and during sensitive subsistence hunting periods.
- Best management practice H-1 requires consultation by permittees with communities that are potentially affected by their proposed activity in order to ascertain any traditional knowledge or other input that could be used to minimize impacts to subsistence use. The best management practice also requires applicants to submit a subsistence plan to the BLM that discusses the results of their consultation, and that steps they are taking to minimize the impacts identified; requires a monitoring plan to be developed for permanent facilities to assess potential effects of the development to subsistence resources and users; and requires permittees to consult with the Alaska Eskimo Whaling Commission and other local whaling entities when their proposal includes barge use.

- Best management practice H-2 addresses conflicts between subsistence users and seismic exploration by requiring seismic operators to communicate the timing, extent, and location of activity to subsistence users; and prohibits seismic activity from within 1 mile of any known subsistence cabin or camp.
- Best management practice H-3 address competition for resources by prohibiting permittees, their employees, agents or contractors from hunting or trapping while on work status.
- Lease stipulation/Best management practice K-1 creates setbacks along various rivers within the NPR-A where no permanent oil and gas facilities will be able to be constructed. Rivers that are considered especially important for subsistence use have a minimum 1-mile setback on either side of the river.
- Lease stipulation/Best management practice K-2 prohibits permanent oil and gas facilities from within 0.25 mile of deep water lakes. This protects fish, waterfowl, and subsistence cabins or camps that may be located on the lake.
- Lease stipulation K-6 prohibits exploratory well pads, production well pads or central processing facilities from coastal waters and 1 mile from the coast inland, protecting subsistence users and resources.

Given these steps, as well as the other lease stipulations and best management practices that serve to directly protect various subsistence resources or their habitat, the BLM has determined that Alternative B-2 includes reasonable steps to minimize adverse impacts on subsistence uses and resources.

Appendix B: Federal, State, and Local Permits and/or Approvals for Oil and Gas Exploration, Development, and Production Activities

The following table summarizes permit and other requirements that must be met before oil and gas exploration or development activities may occur. Some obligations would be placed directly on the applicant. Others would be required of federal agencies prior to granting authorizations to oil and gas companies.

Table B–1. Federal, State and local requirements, permits and approvals for oil and gas exploration, development and production activities

Regulatory agency	Permit/approval actions/requirements
FEDERAL	
National Oceanic and Atmospheric Administration (NOAA) Fisheries Service (formerly National Marine Fisheries Service [NMFS])	• Provides consultation under the Endangered Species Act of 1973, Section 7(a)(2) regarding effects to threatened or endangered species. • Provides consultation under the Magnuson-Stevens Fishery Management and Conservation Act for effects on Essential Fish Habitat. • Provides consultation under the Fish and Wildlife Coordination Act regarding effects on fish and wildlife resources. • Provides consultation under the Marine Mammal Protection Act regarding effects on marine mammals. • Issues Incidental Harassment Authorization under the Marine Mammal Protection Act for incidental takes of protected marine mammals (bowhead whales and ringed seals).
U.S. Army Corps of Engineers (USACE)	• Issues a section 404 permit under the Federal Water Pollution Control Act of 1972, as amended (Clean Water Act; 33 USC § 1344) for discharge of dredged and fill material into waters of the U.S, including wetlands. • Issues a section 10 permit under the Rivers and Harbors Appropriations Act of 1899 (33 USC § 403) for structures or work in, of affecting, navigable waters of the U.S. • Issues a section 103 Ocean Dumping permit under section 103 of the Marine Protection Research and Sanctuaries Act of 1972 (33 USC § 1413) for transport of dredged material for ocean disposal.
U.S. Bureau of Land Management (U.S. BLM)	• Reviews and approves Applications for Permit to Drill (including drilling plans and surface-use plans of operations) and Subsequent Well Operations as prescribed in 43 CFR part 3160, under authority of the Naval Petroleum Reserves Production Act of 1976 (42 USC §§ 6501-6508) and other Federal laws, for development and production of Federal leases. • Approves lease administration requirements including Unit Agreements and Plans of Development, Communitization Agreements, and Participating Area Determinations, as described in 43 CFR parts 3130 and 3180, under the Mineral Leasing Act of 1920 (30 USC §§ 181 et seq.), Federal Oil and Gas Royalty Management Act of 1982 (43 USC §§ 1701 et seq.), Naval Petroleum Reserves Production Act of 1976, Department of the Interior Appropriations Act, Fiscal Year 1981(Public Law 96-514), and other Federal laws, for exploration and development of oil and gas leases. • Issues geophysical permits to conduct seismic activities as described in 43 CFR part 3150, under authority of the Mineral Leasing Act of 1920,

Table B–1. Federal, State and local requirements, permits and approvals for oil and gas exploration, development and production activities

Regulatory agency	Permit/approval actions/requirements
	Alaska National Interest Lands Conservation Act (16 USC §§ 3101 et seq.), Federal Land Policy and Management Act of 1976 (43 USC §§ 1701 et seq.), Naval Petroleum Reserves Production Act of 1976, and Department of the Interior Appropriations Act, Fiscal Year 1981. • Issues rights-of-way grants and temporary use permits for the construction, operation, and maintenance of pipeline, production, and related facilities under the Naval Petroleum Reserves Production Act of 1976. • Delegates authority to ADEC for review and approval of Oil Discharge Prevention and Contingency Plans and Certification of Financial Responsibility for accidental oil discharge into navigable waters under section 1016 of the Oil Pollution Act of 1990 (OPA90; 33 USC § 2716), and Section 311(j)(5) of the Federal Water Pollution Control Act (33 USC § 1321(j)(5); 30 CFR part 254).
U.S. Environmental Protection Agency (USEPA)	• Issues a National Pollutant Discharge and Elimination System (NPDES) permit under section 402, Federal Water Pollution Control Act of 1972, as amended (Clean Water Act; 33 USC § 1342) for discharges into waters of the U.S. Authority for administering this program is being transferred to the State of Alaska in phases, with the last phase, Phase IV, scheduled to be transferred on October 31, 2012. • Issues an Underground Injection Control Class 1 Industrial Well permit under the Safe Drinking Water Act (42 USC §§ 300f et seq.; 40 CFR parts 144 and 146) for underground injection of Class I (industrial) waste materials. • Requires a Spill Prevention Containment and Countermeasure (SPCC) Plan under section 311 of the Federal Water Pollution Control Act of 1972, as amended (Clean Water Act; 33 USC § 1321;40 CFR part 112) for storage of over 660 gallons of fuel in a single container or over 1,320 gallons in aggregate in tanks above ground. • Requires a Facility Response Plan (FRP) under the Clean Water Act as amended (Oil Pollution Act; 33 USC 40) to identify and ensure the availability of sufficient response resources to respond to the worst case discharge of oil to the maximum extent practicable. • Conducts a review and evaluation of the Draft and Final EIS for compliance with CEQ guidelines (40 CFR parts 1500-1508) and section 309 of the Clean Air Act (42 USC § 7609). • Authority delegated to ADEC to issue air quality permits for facilities operating within state jurisdiction, including a Title V operating permit and a Prevention of Significant Deterioration (PSD) permit under the Clean Air Act, as amended (42 USC §§ 7401 et seq.), to address air pollutant emissions.
U.S. Fish and Wildlife Service (USFWS)	• Provides consultation under the Endangered Species Act of 1973, section 7(a)(2) regarding effects to threatened or endangered species. • Provides consultation under the Fish and Wildlife Coordination Act regarding effects to fish and wildlife resources. • Issues a Letter of Authorization under the Marine Mammal Protection Act for incidental takes of marine mammals.

Table B–1. Federal, State and local requirements, permits and approvals for oil and gas exploration, development and production activities

Regulatory agency	Permit/approval actions/requirements
STATE	
Alaska Department of Environmental Conservation (ADEC)	• Issues a Certificate of Reasonable Assurance for discharge of dredged and fill material into U.S. waters under section 401, Federal Water Pollution Control Act of 1972, as amended in 1977 (Clean Water Act; 33 USC § 1341); AS 46.03.020; 18 AAC chapters 15, 70, and 72. • Issues a Certificate of Reasonable Assurance/NPDES and Mixing Zone Approval for wastewater disposal into all state waters under section 402, Federal Water Pollution Control Act of 1972, as amended (Clean Water Act; 33 USC § 1342); AS 46.03.020, .100, .110, .120, and .710; 18 AAC chapters, 10, 15, and 70, and ; § 72.500. • Issues a Class I well wastewater disposal permit for underground injection of non-domestic wastewater under AS 46.03.020, .050, and .100. • Reviews and approves all public water systems including plan review, monitoring program, and operator certification under AS 46.03.020, .050, .070, and .720, 18 AAC § 80.005. • Approves domestic wastewater collection, treatment, and disposal plans for domestic wastewaters (18 AAC chapter 72). • Approves financial responsibility for cleanup of oil spills (18 AAC chapter 75). • Reviews and approves the Oil Discharge Prevention and Contingency Plan and the Certificate of Financial Responsibility for storage or transport of oil under AS 46.04.030 and 18 AAC chapter 75. The State review applies to oil exploration and production facilities, crude oil pipelines, oil terminals, tank vessels and barges, and certain non-tank vessels. • Issues a Title V Operating Permit and a PSD permit under Clean Air Act Amendments (Title V) for air pollutant emissions from construction and operation activities (18 AAC chapter 50). • By May 2013 will receive authorization from EPA to issue NPDES permits under section 402, Federal Water Pollution Control Act of 1972, as amended (Clean Water Act; 33 USC § 1342) for discharges into waters of the U.S. • Issues solid waste disposal permit for state lands under AS 46.03.010, 020, 100, and 110; AS 46.06.080; 18 AAC § 60.005; and 200. • Reviews and approves solid waste processing and temporary storage facilities plan for handling and temporary storage of solid waste on Federal and state lands under AS 46.03.005, 010, and 020; and 18 AAC § 60.430. • Approves the siting of hazardous waste management facilities.
Alaska Department of Fish and Game (ADFG)	• Issues Fish Habitat Permits under AS 41.l4.84O and AS 41.l4.870 for activities within streams used by fish that agency determines could represent impediments to fish passage, or for travel in, excavation of, or culverting of anadromous fish streams.
Alaska Department of Natural Resources (ADNR)	• Issues a Material Sales Contract for mining and purchase of gravel from state lands under AS 38.05.850; and 11 AAC §§ 71.070 and .075. • Issues Rights-of-Way (ROW) and Land Use permits for use of state land, ice road construction on state land, and state freshwater bodies under AS 38.05.850. • Issues a Temporary Water Use and Water Rights permit under AS 46.15 for water use necessary for construction and operations.

Table B–1. Federal, State and local requirements, permits and approvals for oil and gas exploration, development and production activities

Regulatory agency	Permit/approval actions/requirements
	• Issues pipeline ROW leases for pipeline construction and operation across state lands under AS 38.35.020. • Issues a Cultural Resources Concurrence for developments that may affect historic or archaeological sites under the National Historic Preservation Act of 1966, as amended (16 USC §§ 470 et seq.), Alaska Historic Preservation Act (AS 41.35.010 through .240).
Alaska Oil and Gas Conservation Commission (AOGCC)	• Issues a Permit to Drill under 20 AAC § 25.05. • Issues approval for annular disposal of drilling waste (20 AAC § 25.080). • Authorizes Plugging, Abandonment, and Location Clearance (20 AAC § 25.105 through 25.172). • Authorizes Production Practices (20 AAC §§ 25.200 through 25.245). • Authorizes Class II Waste Disposal and Storage (20 § AAC 25.252). • Approves Workover Operations (20 § AAC 25.280). • Reports (20 AAC §§ 25.300 through 25.320). • Authorizes Enhanced Recovery Operations under 20 AAC §§ 25.402-460.
BOROUGH	
North Slope Borough (NSB)	• Issues Development Permits for oil and gas projects under NSB Code of Ordinance Title 19.

Appendix C: NPR-A Climate Change Analysis: An Assessment of Climate Change Variables in the National Petroleum Reserve in Alaska

Note: The following pages are reproduced from a separate report that was published in August 2011.

NPR-A Climate Change Analysis

An Assessment of Climate Change Variables in the National Petroleum Reserve in Alaska

Prepared for the

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Scenarios Network FOR ALASKA & ARCTIC PLANNING

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

University of Alaska Geography Program
uagp

SNRAS
SCHOOL OF NATURAL RESOURCES & AGRICULTURAL SCIENCES

August 2011

Introduction

Alaska is undergoing rapid changes. Substantial warming has occurred at high northern latitudes over the last half-century. Fire patterns are changing, permafrost is thawing, and Arctic summers are now warmer than at any other time in the last 400 years. Most climate models predict that high latitudes will experience a much larger rise in temperature than the rest of the globe over the coming century. At the same time, the state is undergoing rapid changes in human population and demands on natural resources. These changes mean that maintaining the status quo in operations and management of resources and growth may result in increased costs, risk, and resource damage. Future planning that accounts for these changes can avoid or reduce these potential liabilities.

The Bureau of Land Management-Arctic Field Office is responsible for the management of the National Petroleum Reserve-Alaska (NPR-A). The BLM has undertaken an Integrated Activity Plan (IAP)/ Environmental Impact Statement (EIS) to determine its future management of the NPR-A. The IAP/EIS is considering the impacts of climate change in its plan. To improve the IAP/EIS's analysis of climate change's effects on the planning area and its resources, the BLM is incorporating climate change modeling specifically tailored for the NPR-A and areas on Alaska's North Slope that may seasonally be home for animals that could be affected by BLM-authorized activities in NPR-A.

For this project, the Scenarios Network for Alaska Planning (SNAP: www/snap.uaf.edu), a program within the University of Alaska Geography Program, provided objective scenarios based on climate projections and associated models of future landscape conditions that are helping to inform the EIS planning process described above. SNAP is a collaborative network that includes the University of Alaska, state, federal, and local agencies, NGO's, and industry partners. The SNAP network provides timely access to scenarios of future conditions in Alaska and other Arctic regions for more effective planning by communities, industry, and land managers. The network meets stakeholders' requests for specific information by applying new or existing research results, integrating and analyzing data, and communicating information and assumptions to stakeholders. SNAP's goal is to assist in informed decision-making.

The projections used in this project were for a range of modeled data, including baseline (1961-1990), current, and future years extending to 2099. These data provided measurements of change as they are likely to manifest themselves across NPR-A, differentiating the amount of change in different areas of the planning area, and estimating the uncertainty associated with each projection. SNAP provided data on the effects of climate change on the following environmental factors: temperature, precipitation, water availability, vegetation (including green-up rate), and fire regime. Measures of change were, where appropriate, specific to month and/or season. The full results of this assessment are presented below.

Modeling climate change

[For additional detail, see Appendix A: SNAP Climate Data and Modeling and Appendix B: Uncertainty as well as the SNAP website at www.snap.uaf.edu]

SNAP climate models

SNAP climate projections are based on downscaled regional Global Circulation Models (GCMs) from the Intergovernmental Panel on Climate Change (IPCC). The IPCC used fifteen different GCMs when preparing its Fourth Assessment Report released in 2007. SNAP collaborator Dr. John Walsh and colleagues analyzed how well each model predicted monthly mean values for three different climate variables over four overlapping northern regions for the period from 1958 to 2000.

For this project, SNAP used mean (composite) outputs from the five models that provided the most accurate overall results. For each of these five models, results relied on model runs based on midrange (A1B) predictions of greenhouse gas emissions, as defined by the IPCC. The A1B scenario was selected because it offers a balanced and somewhat conservative perspective on the future of human population growth, technology, and energy use; results from this scenario are unlikely to overstate the severity of projected change, given recent climate and emission trends. SNAP model outputs based on these GCMs cover the time period from 1980 to 2099.

Model downscaling

GCMs generally provide only large-scale output, with grid cells typically 1°-5° latitude and longitude. SNAP scaled down these outputs to 2 km resolution, using baseline climatology grids from PRISM (Parameter-elevation Regressions on Independent Slopes Model). These grids represented mean monthly values for precipitation and temperature for the years 1961-1990. PRISM uses point data, a digital elevation model, and other spatial data sets to generate gridded estimates of monthly, yearly, and event-based climatic parameters, such as precipitation, temperature, and dew point. PRISM was originally developed to address the lack of climate observations in mountainous regions or rural areas. SNAP calculated the differences between baseline PRISM grids and GCM grids for the same time period, and used the resulting anomaly grids to downscale future projections.

Model uncertainty

Greenhouse-driven climate change represents a response to the radiative forcing associated with increases of carbon dioxide, methane, water vapor and other gases, as well as associated changes in cloudiness. The response varies widely among GCMs because it is strongly modified by feedbacks involving clouds, the cryosphere, water vapor, and other processes whose effects are not well understood. The ability of a model to accurately replicate seasonal radiative forcing is a good test of its ability to predict changes in radiative forcing associated with increasing greenhouse gases. SNAP models have been assessed using backcasting and comparison to historical conditions, and have proven to be robust in predicting overall climate trends.

Model projections are presented as monthly average values. While trends are relatively clear, precise values for any one year or month for any single model cannot be considered reliable weather forecasts. Each model incorporates the same degree of variability found in normal weather patterns. The downscaling process introduces further uncertainty. While PRISM offers the best available algorithms for linking climate variability to weather station interpolation and digital elevation maps (DEMs), the connection is not perfect. Weather stations are sparse in Alaska, particularly in the northern part of the state, which tends to lower model reliability. Overall, model validation has shown that SNAP projections are more robust for temperature than for precipitation.

Some of this uncertainty can be dampened by using average values across time, space, and GCMs. All three kinds of averaging have been used in this analysis. Averaging increases the reliability of projections, but makes it impossible to make predictions about extreme events such as storms or floods. Since such events are likely to have less impact than more broad-based shifts in the NPR-A, an averaging approach was selected for this project. As described below, additional uncertainty is introduced when SNAP climate models are linked with additional parameters such as fire dynamics, vegetation shift, or permafrost thaw.

Selection of variables and data

For the purposes of this project, SNAP and the BLM analyzed three distinct regions within the NPR-A: the coastal plain, the foothills, and the mountains (Figure 1). It is expected that climate change will have distinct impacts on these different zones. The project focused on projections for two selected decades, 2040-2049 and 2090-2099, in order to provide shorter-term and long-term analysis of climate trends. For most variables, these future decades were compared to the standard baseline climatology used by SNAP, PRISM, and the IPCC: 1961-1990. Temperature and precipitation were assessed in terms of summer (May through September) and winter (October through April) averages for those decades. Additional variables were assessed based on appropriate time steps and seasons, as described in each section below. These variables were selected by the BLM in conjunction with SNAP scientists, and were analyzed by researchers at SNAP in collaboration with the UAF Geophysical Institute Permafrost Lab, the UAF Institute of Arctic Biology, and the UAF School of Natural Resources. They included water availability, fire regime, depth of active layer, potential biome/vegetation shift, and changes in dates of spring thaw and winter freeze. Modeling methods were different for each of these variables, and sources and magnitude of uncertainty vary. The results of each assessment are presented and discussed below.

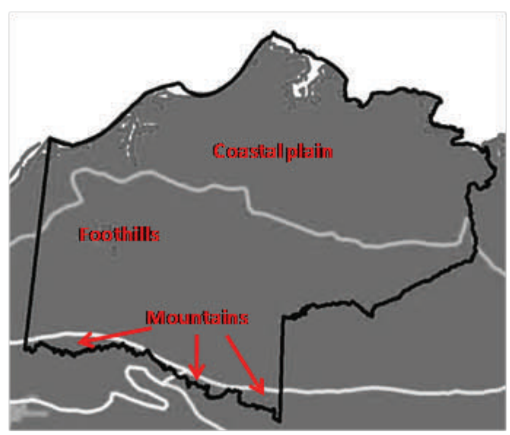

Figure 1: NPR-A sub-zones.

Projection Results for the NPR-A

Temperature

Both summer and winter temperatures are expected to increase across the NPR-A throughout the century, with the greatest increases in winter. Summer temperatures are projected to rise across the NPR-A by approximately 3°F by the 2040s, and by approximately 5-6°F by the 2090s (Table 1). Average winter temperatures (October to April) are likely to increase by as much as 18°F by the 2090s, rising well above zero Fahrenheit, as compared to historical averages of almost ten below (Table 2). Historically, summer temperatures in the NPR-A show a north-south gradient, with the coolest temperatures on the coast and the warmest in the mountains (Figure 2). Winter temperatures show a more complex spatial pattern (Figure 3). For winter temperatures, the increase is projected to be greatest in the coastal plain and least in the mountains. While the opposite pattern is predicted in the summer. As can be seen in Figure 2, summer temperatures characteristic of the southernmost portions of the NPR-A are likely to be seen across the majority of the region by

Table 1: Summer temperature projections by decade and region. "Summer" refers to averages for May through September.

SUMMER TEMPERATURE (°F)	1961-1990	2040-2049	2090-2099
NPRA (all)	40.10	43.10	45.87
Coastal Plain	38.22	41.08	43.72
Foothills	41.71	44.82	47.70
Mountains	42.02	45.26	48.27
	Change from 1961-1990 (°F)		
NPRA (all)	X	3.00	5.77
Coastal Plain	X	2.86	5.50
Foothills	X	3.11	5.99
Mountains	X	3.24	6.25

Table 2: Winter temperature projections by decade and region. "Winter" refers to averages for October through April.

WINTER TEMPERATURE (°F)	1961-1990	2040-2049	2090-2099
NPRA (all)	-9.62	1.24	8.84
Coastal Plain	-9.68	1.34	9.21
Foothills	-9.76	0.98	8.35
Mountains	-6.09	4.40	11.38
Change from 1961-1990 (°F)			
NPRA (all)	X	10.86	18.46
Coastal Plain	X	11.02	18.89
Foothills	X	10.74	18.11
Mountains	X	10.49	17.47

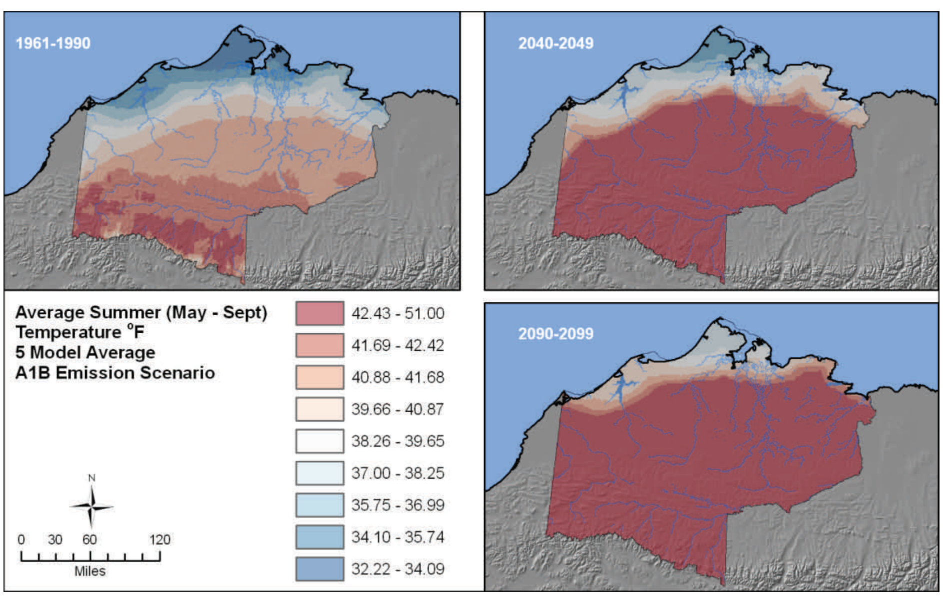

Figure 2: Summer Temperature Projections. "Summer" refers to averages for May through September.

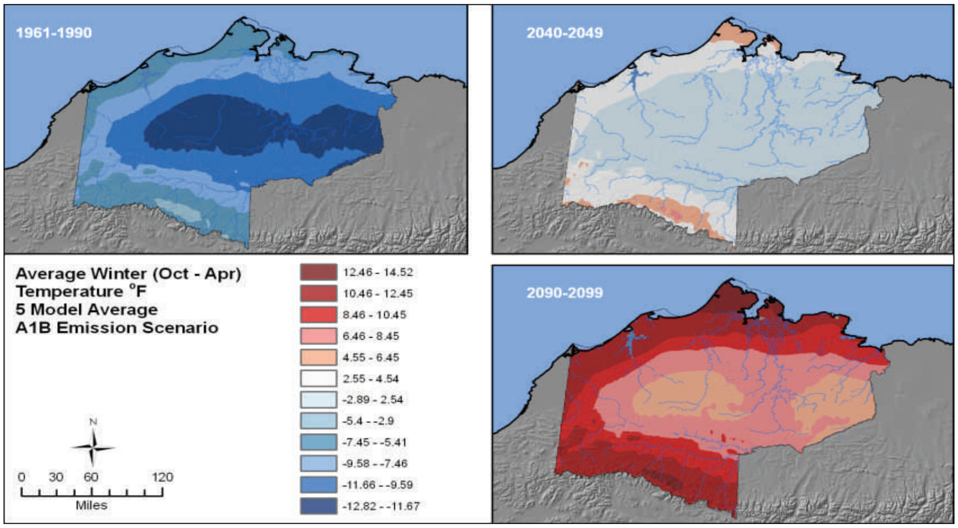

Figure 3: Winter Temperature Projections. "Winter" refers to averages for October through April.

the end of the century, with cooler temperatures persisting only on the coast. Winter temperatures show a more extreme pattern of change. By mid-century, SNAP models predict that even the coldest areas of the NPR-A are likely to experience warmer winters than the warmest areas of the region experienced historically. By the end of the century, unprecedented warm mean winter temperatures are projected throughout the area.

Precipitation

The NPR-A, like the rest of Alaska's Arctic, is a dry region, with historical summer precipitation at less than six inches, and winter precipitation (rain equivalent) at less than five inches. Despite it being essentially a desert, a great number of lakes and wetlands persist in the Arctic due to several factors, including flat topography (on the coastal plain); limited drainage caused by shallow permafrost; and limited evapotranspiration, due to cool temperatures and low biomass.

Predicting changes in overall water availability in the NPR-A is complex, because many of the above factors are expected to change as the climate shifts, and each affects the others, sometimes in unpredictable ways. Thus, water balance will be discussed in the final section of this report, after each of these topics has been discussed.

Precipitation is projected to increase in both summer (Table 3) and winter (Table 4) across all regions of the NPR-A. Greater increases are expected in winter precipitation than in summer precipitation, with increases of 20-45% pro-

Table 3: Summer precipitation projections by decade and region. "Summer" refers to averages for May through September.

SUMMER PRECIPITATION (in.)	1961-1990	2040-2049	2090-2099
NPRA (all)	5.8	7.0	7.4
Coastal Plain	4.4	5.5	5.9
Foothills	6.8	8.0	8.4
Mountains	12.1	13.4	13.8
	Change from 1961-1990 (in.)		
NPRA (all)	X	1.1	1.5
Coastal Plain	X	1.2	1.5
Foothills	X	1.2	1.6
Mountains	X	1.3	1.7
	Change from 1961-1990 (%)		
NPRA (all)	X	+19.4	+26.2
Coastal Plain	X	+26.2	+33.5
Foothills	X	+17.5	+23.4
Mountains	X	+10.8	+13.9

jected by the 2040s, and 35-70% by the 2090s. However, it should be noted that the uncertainty of precipitation forecasts is generally greater than that of temperature predictions (Walsh et al.2008).

Warmer winter temperatures may result in some of this winter precipitation occurring as rain during the shoulder seasons. Precipitation is not divided into rainfall and snowfall, but is reported uniformly as rain-water equivalent.

Table 4: Winter precipitation projections by decade and region. "Winter" refers to averages for October through April.

WINTER PRECIPITATION (in.)	1961-1990	2040-2049	2090-2099
NPRA (all)	4.6	6.2	7.3
Coastal Plain	3.6	5.3	6.3
Foothills	5.3	6.9	8.0
Mountains	7.9	9.5	10.8
	Change from 1961-1990 (in.)		
NPRA (all)	X	1.6	2.7
Coastal Plain	X	1.6	2.7
Foothills	X	1.6	2.7
Mountains	X	1.6	2.8
	Change from 1961-1990 (%)		
NPRA (all)	X	+35.2	+58.3
Coastal Plain	X	+45.3	+73.2
Foothills	X	+29.9	+50.8
Mountains	X	+20.3	+35.7

SNAP models predict the greatest percentage increases in precipitation in the coastal plain, which historically has less than half the annual precipitation of the mountains. However, even a seemingly large increase (33% in summer and 73% in winter) amounts to only an additional 1.5 inches of summer rainfall and 2.7 inches of winter rain-equivalent. In general, the north-south precipitation gradient seen in the NPR-A is expected to remain, as seen in Figures 4 and 5.

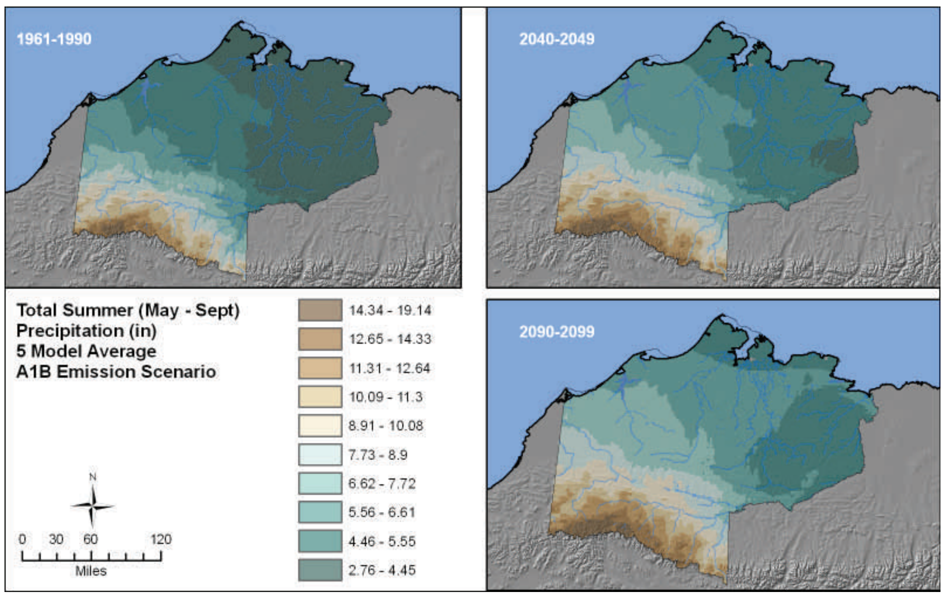

Figure 4: Summer Precipitation Projections. "Summer" refers to averages for May through September.

Freeze and thaw dates

SNAP uses monthly temperature and precipitation projections to estimate the dates at which the freezing point will be crossed in the spring and in the fall, via interpolation. The intervening time period is defined as summer season length. It should be noted that these dates do not necessarily correspond with other commonly used measures of "thaw", "freeze-up" and "growing season." Some lag time is to be expected between mean temperatures and ice conditions on lakes or in soils. However, analyzing projected changes in these measures over time can serve as a useful proxy for other season-length metrics.

Because of the buffering effect of the Arctic Ocean, the NPR-A experiences the warmest spring temperatures in the south, but the warmest fall temperatures in the north.

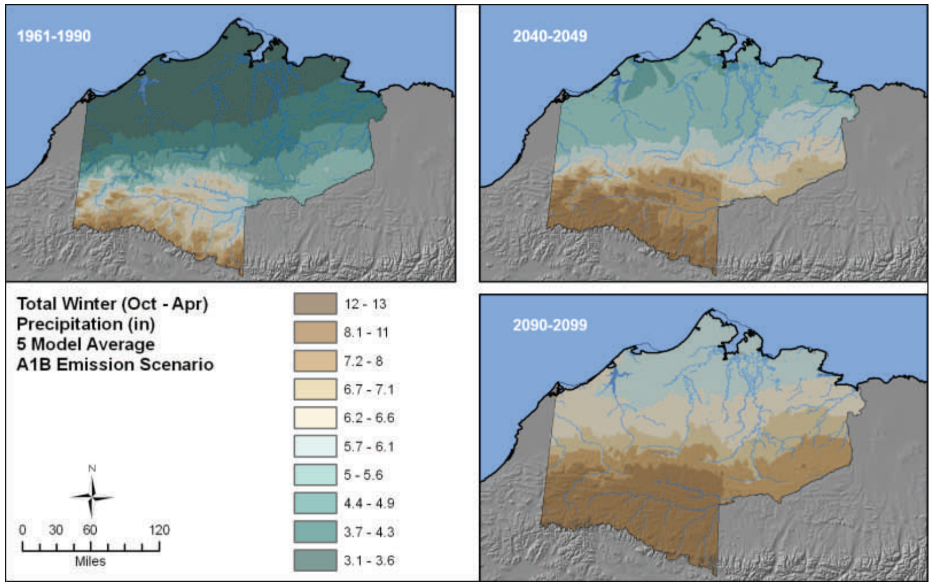

Figure 5: Winter Precipitation Projections. "Winter" refers to averages for October through April

Figure 6 shows projected changes in thaw dates for the baseline period as well as for the 2040s and 2090s. A northward shift in thaw dates is expected over the course of the century. Historically, the coldest coastal regions did not cross the freezing point until the second week of June; these areas are projected to thaw in the first week of June by mid-century, and as early as June 1 by late century. The earliest thaw dates, in the southern NPR-A, as projected to shift from the second week of May to approximately May 1st.

Freeze-up dates in the fall are likely to undergo an even more extreme transition (Figure 7). Historically, the entire NPR-A passed the freezing point in mid-September. By the 2040s, SNAP models show the coastal areas not freezing until early October, and southern regions freezing in late September. By the end of the century, even the mountainous areas may not freeze until October 1st, and the ocean-moderated coastline may be above freezing until the end of October.

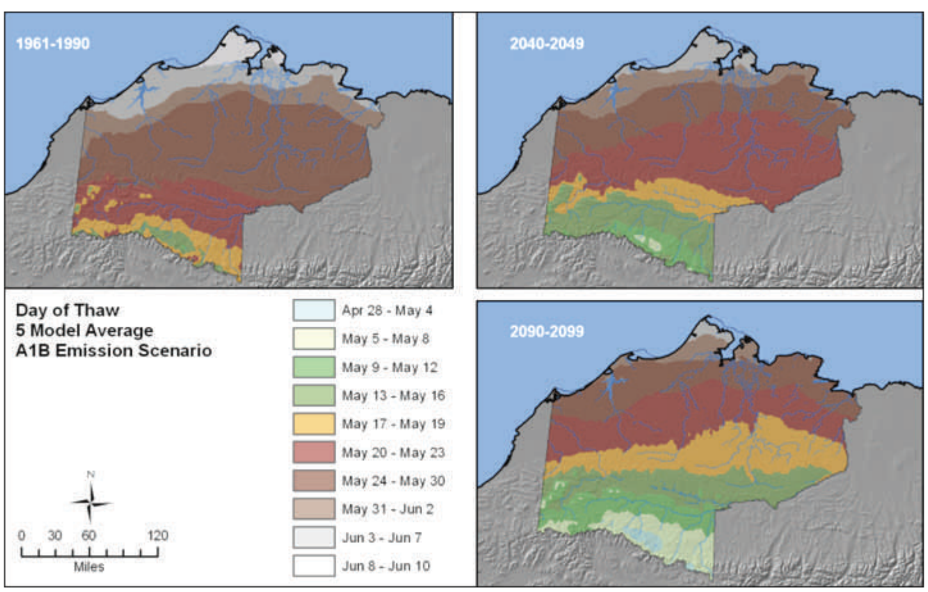

Figure 6: Spring thaw projections. Thaw is defined, for the purposes of this analysis, as the day at which the running mean temperature crossed the freezing point of fresh water.

Since sea ice forms at temperatures well below the freezing point of fresh water, ice formation would be expected later still.

Overall, changes in spring and fall temperatures translate into a summer season that is up to six weeks longer in the northern NPR-A, and approximately three weeks longer in the southern NPR-A.

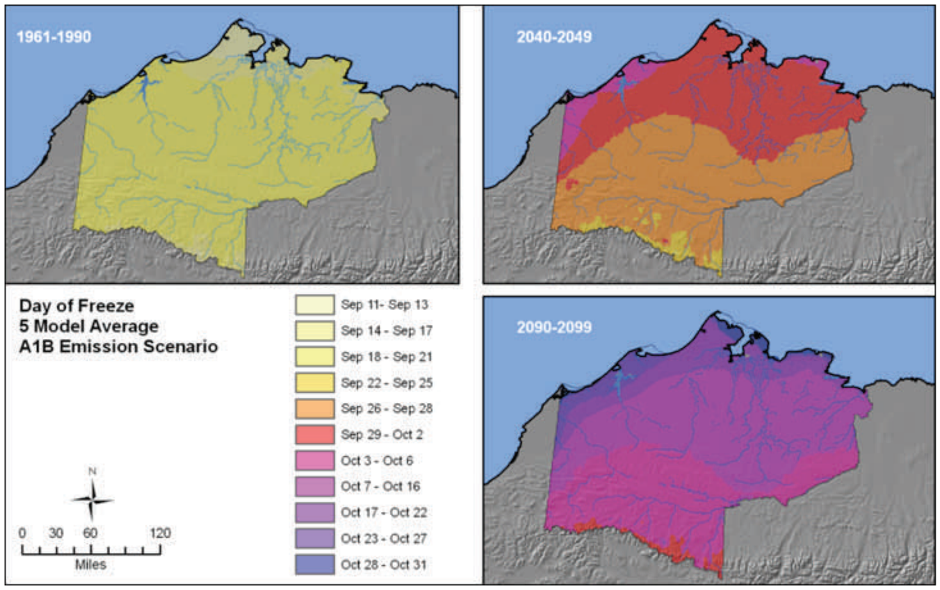

Figure 7: Autumn freeze-up projections. Day of freeze is defined, for the purposes of this analysis, as the day at which the running mean temperature crossed the freezing point of fresh water**.**

Permafrost and depth of active layer

All of the NPR-A is currently underlain by permafrost (permanently frozen soils). During the summer season, the surface layer of the soil thaws, and then refreezes again in the autumn. The depth to which this thaw occurs (depth of active layer) is an important factor in determining what plant species can thrive here.

Permafrost presence/absence, depth to permafrost, and the annual depth of the active layer play important roles in determining ecosystem structure and function. Loss of permafrost stability will impact soil drainage and surface heat flux, while changes in annual thaw depths are likely to affect not only runoff and drainage but also the timing and depth to which plants can access soil moisture. Permafrost vulnerability to climate change is affected by not only mean annual temperature, but also topography, water, soil, vegetation, and snow. Jorgenson et al (2010) found that surface water, ground water, and snow depth had large effects on permafrost stability, and that vegetation succession provides strong negative feedbacks that make permafrost resilient to even large increases in air temperatures. Permafrost creates a strong heat

Table 5: Mean annual thickness of active layer, in meters. Permafrost modeling was performed by Sergei Marchenko of the UAF Geophysical Institute permafrost Lab. Future time periods are modeled using permafrot models coupled with SNAP climate data.

time period	entire NPR-A	coastal	foothill	mountain
1980s	0.493	0.380	0.589	0.704
1990s	0.525	0.406	0.625	0.742
2000s	0.544	0.422	0.648	0.768
1980s-2000s	0.521	0.403	0.621	0.738
2040s	0.590	0.453	0.705	0.854
2090s	0.695	0.553	0.810	1.035
% change from 1980s-2000s				
2040s	13.3	12.4	13.6	15.8
2090s	33.5	37.2	30.5	40.2

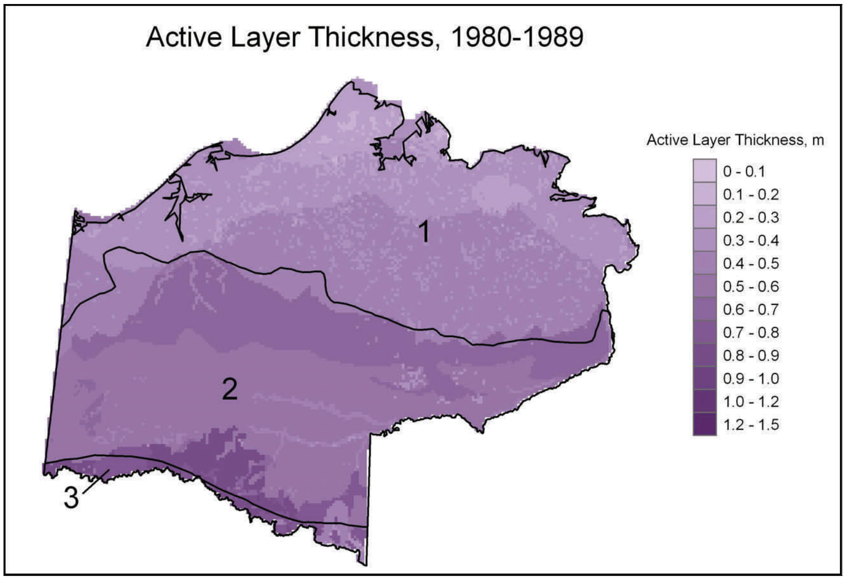

Figure 8 – Historic estimates of depth of active layer, 1980-1989. Active layer represents maximum thaw depths at the end of the summer season, and affects hydrology and vegetation. Region 1 is the Coastal Plains, Region 2 is the Foothills, and Region 3 is the Mountains.

sink in summer that reduces surface temperature and therefore heat flux to the atmosphere (Yoshikawa et al., 2003).

This portion of the project was undertaken by Dr. Sergei Marchenko, and used permafrost models developed by Dr. Vladimir E. Romanovsky and his colleagues at the Geophysical Institute Permafrost Lab (GIPL) at UAF. GIPL used complex models and extensive monitoring stations and field measurements to address scientific questions related to circumpolar permafrost dynamics and feedbacks between permafrost and global climate change. Their models take into account the insulation properties of various soil types and ground covers in order to estimate the lag time between air temperature change and permafrost change. For these projections, GIPL models were linked with SNAP climate projections to produce projections for the 2040s and the 2090s, as compared to the time period between 1980 and 1999.

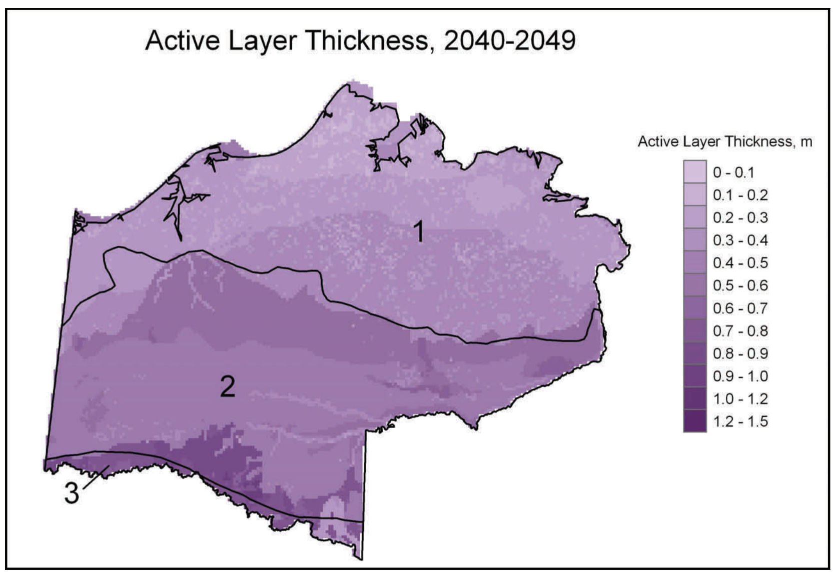

Figure 9 –Projections for depth of active layer, 2040-2049. Modest increases in summer thaw depths are projected by the middle of this century. Such changes may trigger shifts in hydrology and vegetation. Region 1 is the Coastal Plains, Region 2 is the Foothills, and Region 3 is the Mountains.

Results show increases in the depth of the active layer across all regions of the NPR-A, with an overall mean increase of about 30-40% by the end of this century, as compared to the latter part of the previous century (Table 5). As can be seen in Figure 8, historic active layer thickness shows a complex spatial pattern across the NPR-A, with values ranging from only approximately 10 centimeters to as much as a meter and a half. The areas with the greatest active layer thickness are generally in the mountains.

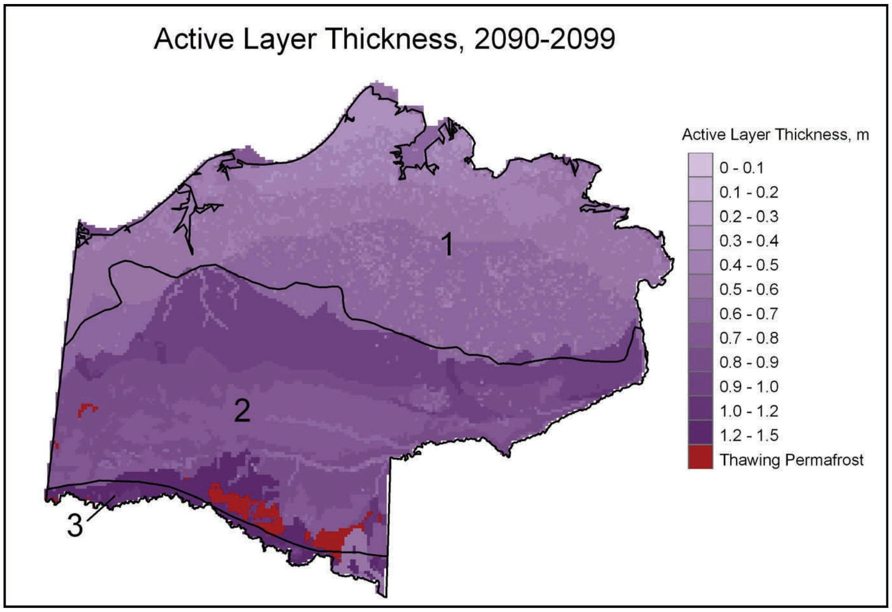

Figure 10 –Projections for depth of active layer, 2090-2099. In some mountainous regions of the NPR-A, loss of shallow permafrost is possible by the end of the century. Region 1 is the Coastal Plains, Region 2 is the Foothills, and Region 3 is the Mountains.

Future projections for the middle of this century show modest but significant increases in active layer depth, with overall spatial patterns remaining the same (Figure 9). By the 2090s (Figure 10), summer thaw depths may increase more dramatically, and in some mountainous areas, shallow permafrost may thaw entirely.

As previously noted, changes in active layer depth and permafrost thaw can have profound effects on vegetation. Where permafrost is very shallow, soils tend to remain saturated throughout the growing season unless on slopes, and only shallow-rooted plants can persist. Conversely, deeper thawed soils allow for better drainage and the growth of woody plants species. The loss of permafrost can lead to thermokarst, slumping, and other major changes in hydrology and land morphology. While the area in which total near-surface permafrost loss is projected is relatively small (shown in red in Figure 9) these regions might be expected to undergo more extreme changes, such as thermokarst and slumping, as compared to other parts of the NPR-A.

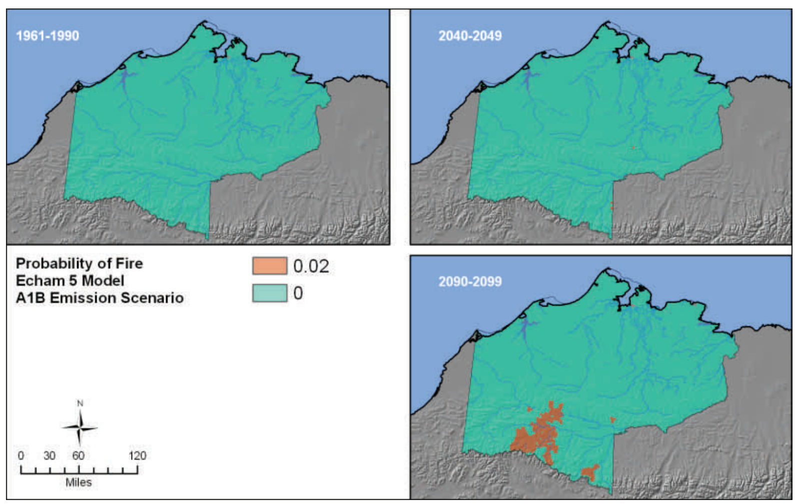

Figure 11 – Probability of fire, per year, based on the ALFRESCO spatially explicit fire model.

Effects on permafrost thaw on vegetation are expected to be complex, since vegetation strongly affects the insulation of soils. In some cases, a shift to denser and woodier plant canopies and thicker organic soils may offset the effects of warmer air temperatures, thus slowing permafrost thawing . On the other hand, positive feedbacks between summer warming, increased vegetation, decreased snow cover, and decreased ice extent may reduce albedo and exacerbate permafrost thaw.

Climate change and fire dynamics

Fire is not currently a major source of ecological disturbance in the NPR-A. However, increasing temperatures statewide are projected to cause an increase in fire frequency, severity, and extent. In the tundra, fire has historically played a small role in successional dynamics but Higuera et al. (2008) found that increased shrubbiness was well-correlated with increased fire frequency in tundra ecosystems across the paleorecord.

For this project, we examined outputs from the Alaska Frame-based Ecosystem Code model (ALFRESCO) in order to analyze potential changes in climate-induced fire patterns in the NPR-A. ALFRESCO is a model of successional dynamics that represents the spatial processes of fire and vegetation recruitment across the landscape. The fire regime is simulated stochastically and is driven by climate, vegetation type, and time since last fire. Simulated fire spread depends on the flammability of the adjacent pixel. ALFRESCO was originally developed to simulate the response of subarctic vegetation to a changing climate and disturbance regime. The focus of the model has been primarily on boreal vegetation, and results have indicated that in Interior Alaska, fire frequency changes strongly influence landscape-level vegetation patterns and associated feedbacks to future fire regime.

In the arctic, changes over the course of this century are expected to be more subtle. As seen in Figure 11, most of the NPR-A is projected to have no fire on the landscape. However, some mountainous areas in the southern portion of the NPR-A may begin to experience regular fire return intervals by 2100, due to warming temperatures, shifting treeline, and the drying effects of increased PET. A probability of fire of 0.02 is roughly equivalent to a 50-year fire return interval. Note that this modeling was done not with the five-model ensemble used for other analyses, but with a single model, ECHAM5. ECHAM5 was the highest ranked model in SNAP's model selection process.

Biome shift

In partnership with the US Fish and Wildlife Service, the UAF Ecological Wildlife Habitat Data Analysis for the Land and Seascape Laboratory (EWHALE), and other collaborators from around the state, SNAP performed a preliminary analysis of the potential for biome shift statewide, based on changing climate parameters. The project modeled projected shifts in broadly categorized species assemblages (biomes) based on existing land cover, current climatic conditions, and projected climate change. The Alaska biomes used in this project -- Arctic, Western Tundra, Alaska Boreal, Boreal Transition, North Pacific Maritime, and Aleutian Islands (Figure 12) -- were adapted from the unified ecoregions of Alaska. Random Forests™ was used to model projected spatial shifts in potential biomes, based on SNAP projections for mean temperature and precipitation for June and December for the decades 2000–2009, 2030–2039, 2060–2069, and 2090–2099.

It should be noted that "potential biomes" (species assemblages that might be expected to occur based on linkages with prevailing climate conditions) are not the same as actual biomes. Even if one assumes that biomes are primarily climate-driven, substantial lag times would be expected, to account

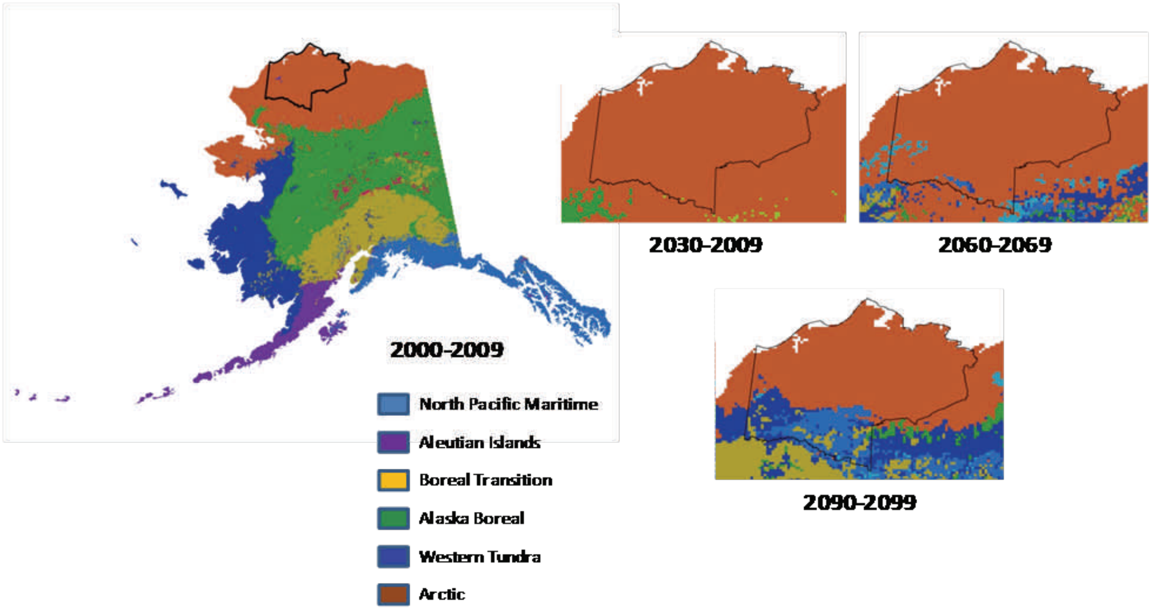

Figure 12: Historic biomes of Alaska and potential biome shift in the NPR-A. Most of the NPR-A is expected to stay within the range of temperature and precipitation (climate envelope) typical of the most recent decade. However, by the end of the century, climate projections for the southern NPR-A better match the climate currently found in other regions of the state, particularly more southerly mountain ranges.

for climate-driven factors such as soil changes, hydrologic changes, and permafrost thaw, and mechanistic factors such as seed dispersal and wildlife reproduction and migration. Nevertheless, results from this project provide a useful indicator of areas in which a mismatch can be expected between existing biome and future conditions. Such areas may be most highly subject to stress, disturbance, and species loss.The mottled pattern of predicted biomes seen in the projections for the southern NPR-A for the 2090s may indicate that no single biome offered a particularly good fit, when matched with projected climate conditions for this area. A new collaborative project between SNAP, EWHALE, and USFWS may shed more light on biome shift by utilizing a cluster-model approach and processing a larger number of variables. Final results of this project are expected in early 2012.

Potential Evapotranspiration and Water Balance

During the growing season, when biological demand is highest, evapotranspiration (ET) becomes the driving mechanism of landscape water loss. The term potential evapotranspiration (PET) is used to describe the likely amount of water that could be returned to the atmosphere through the combination of evaporation and transpiration.

In much of the boreal and arctic, PET during growing season months typically exceeds incoming precipitation, resulting in an overall water deficit during this time (Woo et al. 1992). As the climate continues to warm and the growing season gets longer, scientists expect PET and precipitation (P) will both increase. If the increase in water lost from the landscape through PET is not offset by an equivalent increase in incoming P, the NPR-A may experience more severe water-deficits during the growing season. This prediction is corroborated by observations of increased growing season ET based on satellite imagery (Zhang et al 2009). Over the latter half of the twentieth century, temperature-driven increases in summer evapotranspiration appear to have been partially responsible for net declines in summer water availability in arctic and boreal areas (Hinzman et al. 2005). These observations have led to hypotheses that continued increases in average temperatures may cause future evapotranspiration rates to exceed predicted increases in precipitation, thereby exerting increased drying across the landscape (Rouse et al. 1992; Rouse 2000).

In an effort to better understand where and when changes in hydrology are likely to occur, SNAP, in conjunction with the Wilderness Society, developed a tool for mapping future growing-season water availability. This model focused on water balance during the warm season. PET is determined by the energy available to evaporate water, measured as temperature, and other environmental conditions including wind, cloudiness, plant growth, and humidity.

A variety of methods can be used to estimate PET, each with its own set of benefits and drawbacks (Shutov et al. 2006). For this project, we were limited in terms of the available input data, and had to rely primarily upon estimates of future mean monthly temperature. We used the Preistley-Taylor model, which is described in detail in Appendix C.

Results from this model show that the existing negative water balance during the growing season across the Arctic is expected to persist in coming decades (Table 6) with PET values greater than P values for all regions other than the mountains (Figure 13). In the early part of the century, PET is expected to remain relatively constant (Figure 14). This can be explained by the way in which longwave radiation (reflected heat) is calculated. Longwave radiation is a function of temperature, but the relationship isn't linear. As temperatures increase from 32°F to about 45°F, outgoing longwave radiation increases, but at temperatures above 45°F, outgoing longwave radiation decreases. Thus, landscape drying would be expected to accelerate above this threshold.

Table 6: The projected balance between precipitation (P) and potential evapotranspiration (PET) in the NPR-A. Early in the century, increases in P may offset increased in PET driven by higher temperatures. However, this trend may reverse mid-century. Note that linked factors such as shifting biome and permafrost thaw may exacerbate drying.

Time period	Mean growing season P	Mean growing season PET	Growing season P-PET
1961-1990	5.66	11.73	-6.07
2040-2049	6.40	11.65	-5.25
2090-2099	6.82	12.11	-5.29

The relationship between temperature-driven increases in PET and projected increases in P is likely to hang in the balance. Hydrologic change driven by increases in either P or PET are expected to be relatively subtle, as compared to change driven by factors external to Preistley-Taylor model, including changes in growing season length; permafrost, active layer depth, and associated soil drainage; fire and post-fire succession; and ecosystem shifts. Each of these factors triggers complex feedback loops.

An increase in the depth to permafrost could result in greater runoff and precipitation infiltration,

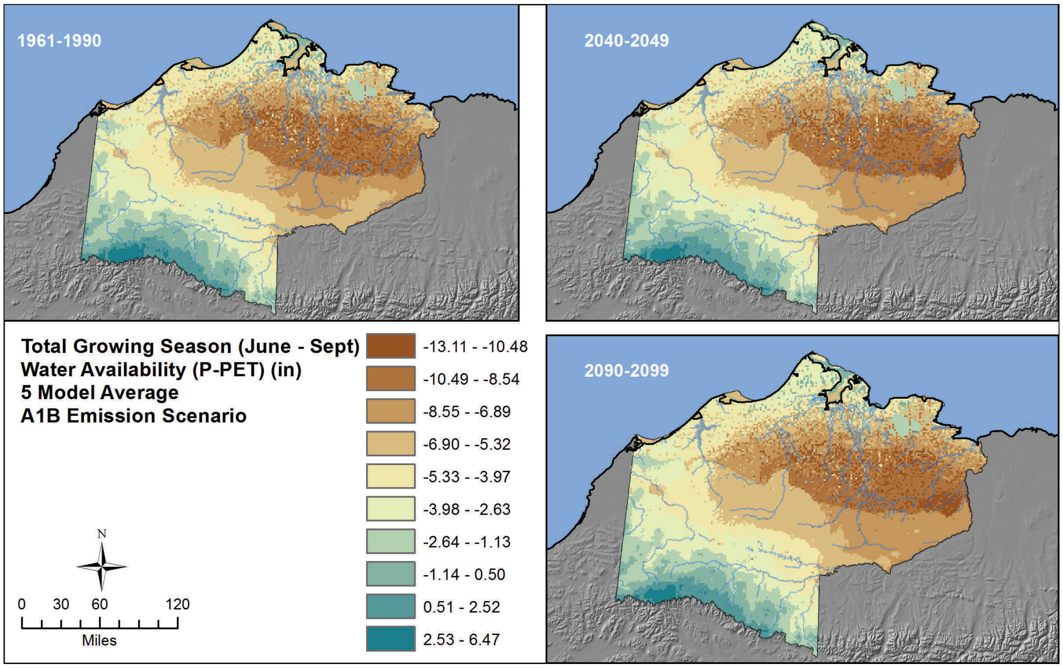

Figure 13: Predicted difference between Precipitation (P) and Potential Evapotranspiration (PET) during the growing season. P-PET is expected to remain negative throughout the century for much of the NPR-A, with the exception of the mountains to the south.

resulting in a decline in the surface water balance. Future losses of permafrost could amplify climatic warming and increase ET rates, indicating yet another positive feedback to the drought cycle.

Conversely, there is also suggestion that long-term melting of permafrost could increase water availability by converting water stored in frozen soils to freely available soil moisture. Rouss et al. (1992) found a feedback loop between dry conditions and depth of active layer in wetland tundra. Dry years promoted deeper thaw depths in permafrost soils during the growing season due to larger ground heat

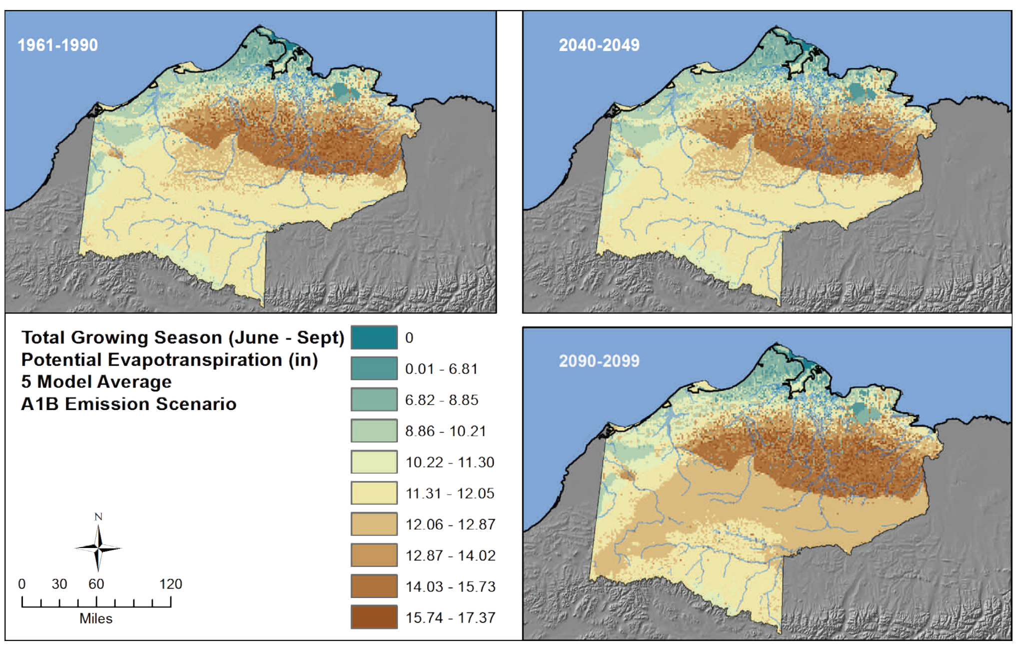

Figure 14: Predicted Potential Evapotranspiration (PET) during the growing season. PET is expected to remain relatively stable in the early century, but water loss due to increased temperature is likely to increase in the later part of the century. However, the slight hydrologic changes driven by changes in PET and precipitation may be overshadowed by hydrologic changes driven by other climate-related factors, such as permafrost thaw and biome shift.

fluxes and larger soil thermal diffusivities. This deeper thawing allowed tundra species to access deeper stores of water, thus at least partially offsetting the effects of moisture stress caused by climate warming.

Vegetation changes and shorter snow season have the potential to significantly impact estimates of growing season water availability, since increased vegetation or change in vegetative cover increases or alters transpiration. As such, failure to account for temporal changes in land cover variables may have lead to underestimation of the magnitude of drying power. Increase in PET over time may also be driven by reduced surface albedo as a result of decreasing snowcover season. On the other hand, failure to account for stomatal control over transpiration as soils dry out (Blanken and Rouse 2004; Eugster et al. 2000) may have led to overestimates of PET rates.

Summary and Conclusions

Overall, the NPR-A is expected to become much warmer in the middle and latter portion of this century, with a longer growing season, shorter less severe winters, and a deeper active layer in soils. Some increases in precipitation are likely, complete permafrost thaw may occur in limited areas, and fire may become a factor on the landscape. Hydrologic changes are likely, although landscape drying is more likely to be driven indirectly by permafrost thaw and vegetation change than by increases in evapotranspiration, at least in the early part of this century.

Due to the complex interrelationships between variables, it is not entirely clear how these changes will play out in terms of changes in drainage, water availability, vegetation, wildlife, and human uses of the landscape. However, it is likely that most, if not all, of the NPR-A will experience some degree of stress to existing plant and animal species due to climate changes, and in some regions significant shifts in biome may occur. New species, including invasive species, may encroach. Cold winter temperatures and short summer seasons currently place a natural bar on many invasives, but with summers up to six weeks longer and winter temperatures up to eleven degrees Fahrenheit warmer, this protection would be lessened.

The combination of thawing permafrost and increased potential evapotranspiration both point toward losing water from the landscape, especially if shifting biomes bring in plant species with higher biomass and a greater capacity for transpiration. However, stomatal control over water loss may partly offset this trend. A drier landscape may have fewer lakes, or smaller lakes, or both. It may also have fewer wetlands, and a corresponding increase in upland habitat types.

Fire is unlikely to play a large role in the near future, but even small and infrequent fires would represent a new factor to be considered in the NPR-A. Post-fire, there would be a window of opportunity for succession by novel species, meaning that fire may facilitate vegetation shift, which would in turn be likely to affect wildlife.

Other potential changes include, for example, a negative impact on many bird species due to decreased wetlands. However, this loss might result in a corresponding increase in forage and improved habitat for grazers, or might even introduce new habitat for browsers. Many wildlife species are affected, either positively or negatively, by snow cover. While it is hard to predict whether seasonal snowpack would be deeper, it is likely that the snow season would start later and end earlier. Rain on snow events might become more common.

All of the above changes are pertinent to human uses of the landscape. Impacts to vegetation and wildlife directly impact hunting and gathering. Changes in season length affect hunting seasons and food storage, and changes to the depth and duration of frozen soils impact winter travel, construction, and ice roads.

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Appendix A: SNAP Climate Data and Modeling

Use of GCMs to model future climate

General Circulation Models (GCMs) are the most widely used tools for projections of global climate change over the timescale of a century. Periodic assessments by the Intergovernmental Panel on Climate Change (IPCC) have relied heavily on global model simulations of future climate driven by various emission scenarios.

The IPCC uses complex coupled atmospheric and oceanic GCMs. These models integrate multiple equations, typically including surface pressure; horizontal layered components of fluid velocity and temperature; solar short wave radiation and terrestrial infra-red and long wave radiation; convection; land surface processes; albedo; hydrology; cloud cover; and sea ice dynamics.

GCMs include equations that are iterated over a series of discrete time steps as well as equations that are evaluated simultaneously. Anthropogenic inputs such as changes in atmospheric greenhouse gases can be incorporated into stepped equations. Thus, GCMs can be used to simulate the changes that may occur over long time frames due to the release of excess greenhouse gases into the atmosphere.

Greenhouse-driven climate change represents a response to the radiative forcing associated with increases of carbon dioxide, methane, water vapor and other gases, as well as associated changes in cloudiness. The response varies widely among models because it is strongly modified by feedbacks involving clouds, the cryosphere, water vapor and other processes whose effects are not well understood. Changes in the radiative forcing associated with increasing greenhouse gases have thus far been small relative to existing seasonal cycles. Thus, the ability of a model to accurately replicate seasonal radiative forcing is a good test of its ability to predict anthropogenic radiative forcing.

Model Selection

Different coupled GCMs have different strengths and weaknesses, and some can be expected to perform better than others for northern regions of the globe.

John Walsh et al. evaluated the performance of a set of fifteen global climate models used in the Coupled Model Intercomparison Project. Using the outputs for the A1B (intermediate) climate change scenario, they calculated the degree to which each model's output concurred with actual climate data for the years 1958- 2000 for each of three climatic variables (surface air temperature, air pressure at sea level, and precipitation) for three overlapping regions (Alaska only, 60-90 degrees north latitude, and 20-90 degrees north latitude.)

The core statistic of the validation was a root-mean-square error (RMSE) evaluation of the differences between mean model output for each grid point and calendar month, and data from the European

Centre for Medium-Range Weather Forecasts (ECMWF) Re- Analysis, ERA-40. The ERA-40 directly assimilates observed air temperature and sea level pressure observations into a product spanning 1958-2000. Precipitation is computed by the model used in the data assimilation. The ERA-40 is one of the most consistent and accurate gridded representations of these variables available.

To facilitate GCM intercomparison and validation against the ERA-40 data, all monthly fields of GCM temperature, precipitation and sea level pressure were interpolated to the common 2.5° × 2.5° latitude – longitude ERA-40 grid. For each model, Walsh et al. calculated RMSEs for each month, each climatic feature, and each region, then added the 108 resulting values (12 months x 3 features x 3 regions) to create a composite score for each model. A lower score indicated better model performance.

The specific models that performed best over the larger domains tended to be the ones that performed best over Alaska. Although biases in the annual mean of each model typically accounted for about half of the models' RMSEs, the systematic errors differed considerably among the models. There was a tendency for the models with the smaller errors to simulate a larger greenhouse warming over the Arctic, as well as larger increases of Arctic precipitation and decreases of Arctic sea level pressure when greenhouse gas concentrations are increased. Since several models had substantially smaller systematic errors than the other models, the differences in greenhouse projections implied that the choice of a subset of models might offer a viable approach to narrowing the uncertainty and obtaining more robust estimates of future climate change in regions such as Alaska. Thus, SNAP selected the five best-performing models out of the fifteen: MPI_ECHAM5, GFDL_ CM2_1, MIROC3_2_MEDRES, UKMO_HADCM3, and CCCMA_CGCM3_1 These five models are used to generate climate projections independently, as well as in combination, in order to further reduce the error associated with dependence on a single model.

Downscaling model outputs

Because of the enormous mathematical complexity of GCMs, they generally provide only large-scale output, with grid cells typically 1°-5° latitude and longitude. For example, the standard resolution of HadOM3 is 1.25 degrees in latitude and longitude, with 20 vertical levels, leading to approximately 1,500,000 variables. Finer scale projections of future conditions are not directly available. However, local topography can have profound effects on climate at much finer scales, and almost all land management decisions are made at much finer scales. Thus, some form of downscaling is necessary in order to make GCMs useful tools for regional climate change planning. Historical climate data estimates at 2km resolution are available from PRISM (Parameter-elevation Regressions on Independent Slopes Model), which was originally developed to address the lack of climate observations in mountainous regions or rural areas. PRISM uses point measurements of climate data and a digital elevation model to generate estimates of annual, monthly and event-based climatic elements. Each grid cell is estimated via multiple regression using data from many nearby climate stations. Stations are weighted based on distance, elevation, vertical layer, topographic facet, and coastal proximity. PRISM offers data at a fine scale useful to land managers and communities, but it does not offer climate projections. Thus, SNAP needed to link PRISM to GCM outputs. This work was also done by John Walsh, Bill Chapman, et al. They first calculated mean monthly precipitation and mean monthly surface air temperature for PRISM grid cells for 1961-1990, creating PRISM baseline values. Next, they calculated GCM baseline values for each of the five selected models using mean monthly outputs for 1961-1990. They then calculated differences between projected GCM values and baseline GCM values for each year out to 2099 and created "anomaly grids" representing these differences. Finally, they added these anomaly grids to PRISM baseline values, thus creating fine-scale (2 km) grids for monthly mean temperature and precipitation for every year out to 2099. This method effectively removed model biases while scaling down the GCM projections. Based on this small-scale grid, SNAP now has mean monthly temperature and precipitation projections for 353 communities statewide based on the means of all five selected models. SNAP also has the ability to turn these datasets into static maps and GIS layers.

Appendix B: Uncertainty

All projections of future climate are uncertain. Understanding the sources of this uncertainty can help in interpreting how these projections can best be used and interpreted.

Raw climate projections

SNAP's most basic climate data are our monthly mean values for temperature and precipitation, available for every month of every year from 1900-2006 (historical data) and 1980-2099 (projected data). The projected data are available for five different models and three different emission scenarios.

Both datasets are subject to uncertainty based on interpolation, gridding and downscaling, as well as uncertainty based on the inherent variability of weather from month to month and year to year.

Interpolation, gridding and downscaling

- Climate stations are very sparse in the far north, and precipitation in particular can vary enormously over very small areas and time frames so interpolation is challenging and imperfect regardless of method
- PRISM uses point data, a digital elevation model, and other spatial data sets to generate gridded estimates
- CRU data uses different algorithms from PRISM, and does not utilize data on slope and aspect and proximity to coastlines
- Overall, PRISM seems to do the best job of capturing landscape climate variability

Natural variability

- Even when trends (e.g. warming climate) are occurring, they can be obscured by normal ups and downs in weather patterns
- GCM outputs simulate this normal variability, but the variations cannot be expected to match actual swings
- Uncertainty is inevitably greater for precipitation than for temperature

Projected data are also subject to uncertainty related to the accuracy of the Global Circulation Models upon which they are based.

Inputs to GCMs

- Solar radiation is essentially a known quantity
- Levels of greenhouse gases are uncertain, but accounted for by varying emissions scenarios

GCM algorithms

- Oceanic and atmospheric circulation are extremely hard to predict and model
- May include thresholds (tipping points) such as ocean currents shifting or shutting down
- Don't fully account for short-term phenomena such as the Pacific Decadal Oscillation (PDO)

Processed data and linked models

SNAP products that link our raw data (monthly climate data) to other models must be interpreted in the context of the combined uncertainty of the raw data and the models to which it is linked. The list below is not exhaustive, since new projects are continually being developed.

Fire

- The ALFRESCO model uses SNAP input to project fire on the landscape
- This model depends on assumptions and estimates regarding the frequency and location of fire starts and the relationship between climate, forest age and type, and fire spread
- These values have been calibrated using historical data

Permafrost

- SNAP permafrost modeling has been performed in conjunction with experts at the Geophysical Institute Permafrost Lab
- Algorithms to determine the depth of active layer are dependent on calculations of the insulating properties of varying ground cover and soil types, as well as on climate variables

Vegetation Change

- SNAP has worked with multiple partners in the US and Canada to predict potential landscape shifts driven by climate change
- These projections are dependent upon the linkages between vegetation and climate, as well as the ability of various species to shift across the landscape under either gradual or threshold-driven change

Dealing with uncertainty

Natural Variability

Averaging across all five models (using the composite model) can reduce the ups and downs built into the models

Averaging across years (decadal averages) can reduce uncertainty due to natural variability

GCM uncertainty

Variation between models can be used as a proxy for uncertainty in GCM algorithms

Averaging across all five models (using the composite model) can reduce any potential bias

SNAP's model validation study depicts uncertainty by region, model, and data type based on comparisons between model results and actual station data

Interpolation, gridding, and downscaling

In some cases, differences between CRU and PRISM data can be viewed as a proxy for uncertainty in downscaling

Linked models

- Approaching the same question using multiple linked models can serve as a form of validation
- Ground-truthing using historical data is important – as has been done in all ALFRESCO runs as a means of calibration
- Scenarios planning (allowing for more than one possible future) allows for greater flexibility in the face of high uncertainty

Appendix C: Calculation of Potential Evapotranspiration (PET) using the Priestley-Taylor Method

A variety of methods can be used to estimate evaporation from land surfaces and resulting moisture balance, each with its own set of benefits and drawbacks (Shutov et al. 2006). Methods are selected based on available data and model reliability. For this project, the primary model used to estimate PET was the Preistley-Taylor model:

$$PET = \left(\frac{1}{\lambda}\right) * \alpha * \left(\frac{s}{s+\gamma}\right) * (R - G)$$

where,

PET	potential evapotranspiration [mm day^{-1}]
λ	latent heat of vaporization of water at 20°C = 2.45 [MJ kg^{-1}]
α	adjusts PET for surface characteristics = 1.26 [unitless]
s	slope of the curve of the saturation vapor pressure curve [kPa °C^{-1}]
γ	psychrometric constant [kPa °C^{-1}]
R	net radiation [MJ m^{-2} day^{-1}]
G	heat flux from the ground surface [MJ m^{-2} day^{-1}]

Note that all calculations were performed with monthly averages; the daily rates derived here can then be multiplied by the number of days in a month to get accumulated monthly PET.

$\left(\frac{s}{s+\gamma}\right)$ **-** slope of the vapor pressure curve and the psychrometric constant

$$\frac{s}{s+\gamma} = 0.406 + 0.011T$$

where,

T is mean monthly air temperature [°C]

This equation was developed for and tested in boreal forest and tundra environments. It is unclear whether it is entirely appropriate for strongly marine influenced systems or high alpine environments.

R - net radiation

$$R = (1 - a) * Rs - Rl$$

where,

a is fractional albedo

Rs is incoming shortwave radiation [MJ m^{-2} day^{-1}]

Rl is net longwave radiation in the *outgoing direction* [MJ m^{-2} day^{-1}]

Rs is incoming shortwave radiation [MJ m^{-2} day^{-1}]

Rl is net longwave radiation in the *outgoing direction* [MJ m^{-2} day^{-1}]

Note that if Rl is calculated by the standard sign conventions, this equation must be written as

$$R = (1 - a) * Rs + Rl$$

Surface	Albedo
Open Water	0.06
Wetland Tundra	0.15
Upland Tundra	0.16
Boreal Coniferous Forest	0.08
Boreal Deciduous Forest	0.16
Barren Land	0.20
Perennial Ice/Snow	0.40

a - albedo

This project used static albedo values. This is likely to introduce some error, as albedo would typically be higher when snow is present. Since albedo values in Eugster et al. (2000) are primarily mid-summer overcast-day minimum albedo values, they are at the low end of published values (see Betts and Ball 1997; Duchon and Hamm 2006). The albedo value used here for water is probably for low- or mid-latitude solar incidence angles and could likely be higher under polar light conditions (Barry and Chorley 2003). However, we are using the values selected by B. O'Brien.

Rs - incoming shortwave radiation at the surface

$$Rs = kRa(Tmax - Tmin)^{0.5}$$

where,

k Hargreaves coefficient a constant [°$C^{-0.5}$]
Ra is solar radiation at the top of the atmosphere [MJ m^{-2} day $^{-1}$]

Tmax and Tmin are monthly average maximum and minimum temperature [°C]

The Hargeaves coefficient is a constant set to 0.16 in the interior and 0.19 in regions deemed to have a marine influence (Allen et al. 1998). It is likely that the spatial distribution and extent of areas that experience predominantly marine vs. interior airmasses may change in the future; thus our use of static k values may be somewhat inaccurate.

Ra - incoming solar radiation at the top of the atmosphere

$$Ra = \frac{24 * 60}{\pi} * d * S[\omega \sin(\varphi) \sin(\delta) + \cos(\varphi) \cos(\delta) \sin(\omega)]$$

where,

S is the solar constant [0.082 MJ m^{-2} min^{-1}]
ω is the sunset hour angle [radians]
d is the inverse of the Earth-Sun distance
ϕ is latitude [radians]
δ is the declination [radians]

w - sunset hour angle

$$\omega = cos^{-1}[-tan(\delta)\, tan(\varphi)]$$

d - inverse earth-sun distance

$$d = 1 + 0.033cos\left(\frac{2\pi}{365}J\right)$$

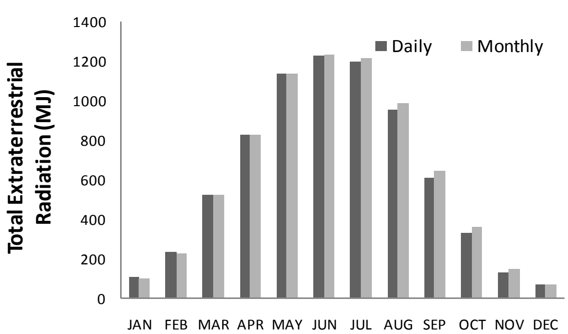
δ - declination

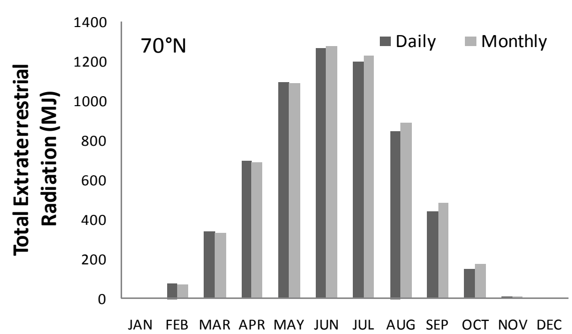
$$\delta = 0.409 * sin\left[\frac{2\pi}{365}J - 1.39\right]$$

where,

J is the Julian Day of the year.

When the sun does not rise ω is set equal to 0, and when the sun does not set ω is set equal to π. In order to calculate Ra at a monthly time step, we calculated average daily radiation for each day within the month and then average across the month.





Rl - net longwave radiation in the outgoing direction

$$Rl = -f\varepsilon\sigma(Tave + 273.15)^4$$

where,

f is a cloud factor, calculated below
ε is the emissivity, calculated below
σ is the Stefan-Boltzmann constant [4.903 10^{-9} MJ K^{-4} m^{-2} day^{-1}]
Tave is average temperature [°C]

Cloud factor

$$f = \frac{Rs}{Rcs}$$

where,

Rs is incoming shortwave radiation [MJ m^{-2} day^{-1}]
Rcs is clear-sky shortwave radiation

Clear-sky shortwave radiation

$$Rcs = (0.75 + 2 * 10^{-5}z) * Ra$$

where,

z is elevation [m]
Ra is solar radiation at the top of the atmosphere [MJ m^{-2} day^{-1}]

Emissivity

$$\varepsilon = -0.02 + 0.261e^{-0.000777Tave^2}$$

This equation produces net longwave radiation with the common sign convention. To use the net radiation equation used here, remove the leading minus sign.

Temperature

All temperatures needed are calculated from SNAP-downscaled CRU or GCM output, in combination with the 1961-90 PRISM climatology.

$$PRISM.Tave = 0.5 * (0.1 * PRISM.Tmax + 0.1 * PRISM.Tmin)$$

$$Tmax = 0.1 * PRISM.Tmax + (Tave - PRISM.Tave)$$

$$Tmin = 0.1 * PRISM.Tmin + (Tave - PRISM.Tave)$$

Appendix D: Essential Fish Habitat

D.1 Regulatory Background

The 1996 Sustainable Fisheries Act (Public Law 104-297) enacted additional management measures to protect commercially harvested fish species from overfishing. Along with reauthorizing the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265 [Magnuson-Stevens Act), one of those added measures is to describe, identify, and minimize adverse effects to "essential fish habitat." Definitions and rules involving essential fish habitat are in 50 CFR Part 600. The National Marine Fisheries Service implements the requirements of the Magnuson-Stevens Act.

> **Essential fish habitat definition:** "…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat: 'Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle" (50 CFR Part 600.10).
>
> **Adverse effect definition:** "…any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions" (50 CFR Part 600.810).
>
> **Federal action requirement:** "For any Federal action that may adversely affect EFH, Federal agencies must provide National Marine Fisheries Service with a written assessment of the effects of that action on EFH…. Federal agencies may incorporate an EFH Assessment into documents prepared for other purposes such as…the National Environmental Policy Act" (50 CFR Part 600.920).

In 1997, the National Marine Fisheries Service issued an interim final rule to implement the essential fish habitat provisions of the Magnuson-Stevens Act (62 FR 66531). This included the clarification that Regional Fishery Management Councils would describe and identify essential fish habitat in fishery management plans. In Alaska, fishery management plans are developed by the North Pacific Fishery Management Council and approved by Secretary of Commerce. In 2002, National Marine Fisheries Service issued a final rule with no substantial changes to the interim rule (67 FR 2343).

D.2 Arctic Essential Fish Habitat

Fish species with essential fish habitat designated in and near the NPR-A include all five species of Pacific salmon [chum (*Oncorhynchus keta*), pink (*O. gorbuscha*), Chinook (*O. tshawytscha*), coho (*O. kisutch*), and sockeye (*O. nerka*)], Arctic cod (*Boregogadus saida*), and saffron cod (*Eleginus gracilis*). Salmon are managed under the "Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska" (Salmon Fishery Management Plan; North Pacific Fishery Management Council 1990). Arctic cod and saffron cod in the Chukchi and Beaufort seas are managed under the "Fishery Management Plan for Fish Resources of the Arctic Management Area" (Arctic Fishery Management Plan; North Pacific Fishery Management Council 2009).

D.2.1 Pacific Salmon

All of the salmon species have anadromous life histories that are described broadly in Table D-1 according to Mecklenburg et al. (2002). For more detailed information on each species, see Groot and Margolis (1991).

Table D–1. Pacific salmon life history characteristics

Species	Spawning habitat	Migration to sea from spawning habitat	Time at sea
Chum salmon	Freshwater	Immediately	3 to 5 years
Pink salmon	Freshwater or intertidal zone	Immediately	18 months
Chinook salmon	Freshwater	3 months to 2 years	1 to 5 years
Coho salmon	Freshwater	1 to 4 years	2 to 3 years
Sockeye salmon	Freshwater (lakes)	1 to 2 years	1 to 4 years

In the northeast Chukchi Sea and western Beaufort Sea, all five species of Pacific salmon have been reported (Craig and Haldorson 1986). However, salmon have a very difficult time establishing sustainable runs in the Arctic, most likely because of marginal freshwater habitats (Craig 1989a; Fechhelm and Griffiths 2001). Pink and chum salmon occur in the greatest numbers. Although the number of actual spawning stocks (versus probable stray runs) is unknown, they are relatively common in the Chukchi Sea and Beaufort Sea (Fechhelm and Griffiths 2001; Moss et al. 2009).

Chinook salmon are much more uncommon in the NPR-A and its coastal waters and sockeye and coho salmon are rare. Due to the colder temperatures in the Beaufort Sea, these salmon species are more likely to be present in the northeast Chukchi Sea, although captures anywhere north of Point Hope are most commonly limited to only one or a few individuals (Craig and Haldorson 1986). In 17 years of summer coastal sampling in the Prudhoe Bay region of the Beaufort Sea (1981−1997), only one king salmon and zero sockeye or coho salmon were captured (Fechhelm and Griffiths 2001). However, in the recent decade there have been some years with notable increases in king salmon captured in the Elson Lagoon subsistence fishery further to the west (George 2006, pers. comm.).

The most current essential fish habitat descriptions for salmon in the Arctic are included in amendments 7 and 8 to the Salmon Fishery Management Plan (North Pacific Fishery Management Council 2006), which implemented the preferred alternative from the "Environmental Impact Statement for Essential Fish Habitat Identification and

Conservation in Alaska" (National Marine Fisheries Service 2005). This describes essential fish habitat that encompasses all life history stages for all Pacific salmon species as marine waters extending to the outer limit of the U.S. Exclusive Economic Zone, estuarine waters extending to the salinity transition zone, and freshwaters that are identified as being used by salmon in Alaska Department of Fish and Game's "Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes" (Alaska Department of Fish and Game 1998), also known as the "Anadromous Waters Catalog." The outer limit of the U.S. Exclusive Economic Zone is 200 nautical miles; for analysis purposes here, the salinity transition zone is considered to be 10 kilometers offshore, as this is typically the greatest extent of the estuarine band that forms along the coast of the Beaufort Sea during the summer (Craig 1984a); and a more recent version of freshwaters documented as being utilized by salmon is available in the current version of the Anadromous Waters Catalog (Alaska Department of Fish and Game 2011a). These essential fish habitat designations for salmon are shown on Map D-1. Table D-2 lists the stream and river systems with essential fish habitat in the NPR-A.

Table D–2. Stream and river systems in the NPR-A with freshwater essential fish habitat based on the Anadromous Waters Catalog

Stream system	AWC Code	Salmon species utilizing
Colville River	330-00-10700	pink, chum
Fish Creek	330-00-10840	pink, chum, Chinook
Ublutuoch River	330-00-10840-2017	pink, chum, Chinook
Judy Creek	330-00-10840-2043	pink, chum
Ikpikpuk River	330-00-10900	pink, chum
Chipp River	330-00-10915	pink, chum
Meade River	330-00-10920	chum
Kugrua River	330-00-10940	pink, chum
Kuk River	330-00-10980	pink
Kungok River	330-00-10980-2004	pink
Mikigealiak River	330-00-10980-2004-3009	pink
Ivisaruk	330-00-10980-2009	pink
Kaolak River	330-00-10980-2101	pink
Utukok River	330-00-11100	pink, chum
Kokolik River	330-00-11200	pink, chum

Source: Alaska Department of Fish and Game (2011a)

D.2.2 Arctic Cod and Saffron Cod

Arctic cod are considered semi-pelagic because of their wide distribution throughout demersal and pelagic habitats (Gusey 1988). Individuals mature around 2 to 3 years of age, spawning occurs only once in a lifetime, and 6 to 7 years is the maximum age (Cohen et al. 1990). They are one of the most abundant fish species found in Arctic coastal waters, although they can be found in a broad range of habitats, including offshore, lagoons and inlets, and river mouths (Fechhelm et al. 1984; Moulton and Tarbox 1987; Gusey 1988; Johnson et al. 2010). Abundance tends to be greatest in nearshore habitats during the summer and in offshore habitats during winter (Craig et al. 1982; Craig 1984a). They are believed to be the most important consumer of secondary production in the Alaskan

Beaufort Sea (Frost and Lowry 1983) and serve as a substantial prey item for marine mammals, birds, and other fishes (Bradstreet and Cross 1982; Frost and Lowry 1984).

Saffron cod are demersal (i.e., living on or near the seabed) as adults (Gusey 1988). Individuals mature around 2 to 3 years of age, after which they spawn once a year, and 10 to 14 years is the maximum age (Cohen et al. 1990). Distributions are primarily in moderately saline nearshore habitats for much of the year, although they may migrate for summer feeding into brackish coastal habitats or up rivers within the zone of tidal influence (Fechhelm et al. 1984; Mecklenburg et al. 2002). Saffron cod are also a chief prey item for marine mammals, birds, and other fishes (Frost and Lowry 1984; Gusey 1988).

The most current descriptions of essential fish habitat for Arctic cod and saffron cod are in the 2009 Arctic Fishery Management Plan. For both species, there is inadequate data to determine essential fish habitat for eggs, larvae, and early juveniles. The current extent of essential fish habitat is the general distribution areas for late juveniles and adults. The general distribution area for Arctic essential fish habitat is defined as "the area where presence has been documented by research effort and confirmed by species experts". These essential fish habitat designations are shown on Map D-1.

Proposed Action

The NPR-A consists of 23 million acres located on the North Slope of Alaska. The BLM is undertaking the NPR-A Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) to determine the appropriate management of all BLM-managed lands in the NPR-A in light of new information about surface and subsurface resources, and in a manner consistent with existing statutory direction from the Naval Petroleum Reserves Production Act of 1976, as amended. The BLM will consider consistent oil and gas leasing stipulations and best management practices across the entire NPR-A, while providing special protections for specific habitats and site-specific resources and uses. The BLM will also provide an opportunity, subject to appropriate conditions developed through a NEPA process, to construct necessary onshore infrastructure, primarily pipelines and roads, to bring oil and gas resources from leases in the Chukchi Sea to the Trans-Alaska Pipeline System.

Potential Adverse Effects on Essential Fish Habitat

The potential adverse effects on essential fish habitat from oil and gas activities would be the same as those described for other fish habitat in Chapter 4. No effects on marine essential fish habitat would be expected. Potential effects on estuarine essential fish habitat would primarily be related to causeways, or other similar structures, described in detail in section 4.3.7.2 in Volume 2. Ineffective design of coastal structures can lead to substantially altered water quality and create barriers to fish movements. Potential effects on freshwater essential fish habitat from a variety of oil and gas activities described in detail in section 4.3.7.2 in Volume 2 broadly include altered water quality, physical habitat changes (water quantity, flow patterns, and geomorphology), point and non-point source pollution, increased turbidity and sedimentation, and barriers to fish movements.

The primary difference among alternatives is the level of anticipated oil and gas development. Based on the extent of coastline susceptible to development, the greatest potential impacts to estuarine essential fish habitat would occur under Alternative D, with increasingly less risk under alternatives A, C, and B-2, and B-1, respectively. Based on the distribution of lands available for oil and gas leasing relative to waters listed for salmon in the Anadromous Waters Catalog (Alaska Department of Fish and Game 2011a), the greatest potential impacts to freshwater essential fish habitat would occur under Alternative D, with increasingly less risk under alternatives C, A, and B-2, and B-1, respectively.

Proposed Mitigation Measures

Lease stipulations and required operating procedures (under Alternative A) or best management practices (under alternatives B-1, B-2, C, and D) would mitigate potential effects on essential fish habitat. Proper implementation of these protective measures should ensure that impacts to essential fish habitat are avoided or minimized. The following list summarizes the mitigation measures; details for each measure can be found in Table 2-3 in Chapter 2, Volume 1. These management standards largely address relevant comparable Recommended Conservation Measures identified in "Impacts to Essential Fish Habitat from Non-fishing Activities in Alaska" (National Marine Fisheries Service 2011).

- **Required Operating Procedure/Best Management Practice A-2:** Requires comprehensive waste management plan.
- **Required Operating Procedure/Best Management Practice A-3:** Requires a hazardous materials emergency contingency plan.
- **Required Operating Procedure/Best Management Practice A-4:** Requires a comprehensive spill prevention and response contingency plan.
- **Required Operating Procedure/Best Management Practice A-5:** Establishes refueling setbacks from waterbodies.
- **Required Operating Procedure/Best Management Practice A-6:** Prohibits discharge of reserve-pit fluids.
- **Required Operating Procedure/Best Management Practice A-7:** Prohibits discharge of produced water in upland areas and marine waters.
- **Required Operating Procedure/Best Management Practice B-1:** Prohibits water withdrawals from rivers and streams during winter.
- **Required Operating Procedure/Best Management Practice B-2:** Establishes lake water withdrawal limits and practices to protect fish.
- **Required Operating Procedure/Best Management Practice C-2:** Requires sufficient ground frost and snow cover prior to winter overland moves, contributing to the protection of stream banks and frozen waterbodies.
- **Required Operating Procedure/Best Management Practice C-3:** Establishes winter river and stream crossing guidelines related to protecting runoff patterns, fish passage, and natural channel characteristics, including the requirement that crossings reinforced with additional snow or ice ("bridges") be removed, breached, or slotted before spring breakup.
- **Required Operating Procedure/Best Management Practice C-4:** Establishes winter river and stream crossing guidelines related to avoiding additional freeze-down into fish habitat, including restrictions on traveling up and down streambeds.

- **Lease Stipulation D-1:** Prohibits exploratory drilling within the floodplain of rivers and streams and within fish-bearing lakes.
- **Lease Stipulation D-2:** Prohibits construction of permanent or gravel facilities (including pads, roads, and airstrips) for exploratory drilling.
- **Required Operating Procedure/Best Management Practice E-1:** Requires that all roads be designed, constructed, maintained, and operated in a manner that minimizes environmental impacts.
- **Lease Stipulation E-2:** Prohibits permanent facilities (including pads, roads, airstrips, and pipelines) within 500 feet of fish-bearing waterbodies, except for essential road and pipeline crossings that will be permitted on a case-by-case basis.
- **Lease Stipulation E-3:** Prohibits causeways, docks, artificial gravel islands, and bottom-founded structures in river mouths or deltas. Requires that the design of any coastal structure ensures free fish passage and doesn't cause significant changes to nearshore oceanographic circulation patterns and water quality characteristics.
- **Required Operating Procedure/Best Management Practice E-4:** Requires that pipelines be designed, constructed, and operated according to the best available technology for detecting and preventing corrosion that can lead to leaks.
- **Required Operating Procedure/Best Management Practice E-5:** Establishes guidelines to minimize the development footprint, which would minimize the total impervious surface area within individual drainages.
- **Required Operating Procedure/Best Management Practice E-6:** Requires that stream and marsh crossings be designed and constructed to ensure free fish passage, reduce erosion, maintain natural drainage, and minimize effects to natural stream flow.
- **Required Operating Procedure/Best Management Practice E-8:** Establishes gravel mine guidelines for design that will minimize negative effects on fish habitat and for reclamation that will promote potential positive effects on fish habitat.
- **Required Operating Procedure/Best Management Practice E-14:** Requires that stream and river road crossings utilize the most current design tools that will facilitate free fish passage, including a minimal of 3 years of hydrology and fish data to guide decisions.
- **Lease Stipulation/Best Management Practice K-1:** Establishes setback distances for permanent facilities (including pads, roads, airstrips, and pipelines) of 0.5 mile, 0.75 mile, 1 mile, and, under Alternative B-1 and B-2, 2 miles from many major streams and rivers, except for essential road and pipeline crossings that will be permitted on a case-by-case basis.
- **Lease Stipulation/Best Management Practice K-3b (Alternatives A, B-1, B-2, and C only):** Establishes additional protective measurements for "major coastal waterbodies" regarding exploration and development.
- **Lease Stipulation/Best Management Practice K-8b** (Does not apply to Alternative B-2)**:** Prohibits permanent facilities within the existing Kasegaluk Lagoon Special Area.

Essential Fish Habitat Finding

No marine essential fish habitat impacts are probable based on the scope of the proposed action. Estuarine essential fish habitat would receive sufficient protection by considerations for coastal structures under Lease Stipulation E-3, which would avoid impacts such as those caused by causeways in the Prudhoe Bay area (section 4.3.7.2 in Volume 2). The multitude of other lease stipulations and required operating procedures/best management practices listed above would provide substantial environmental protections that would minimize or avoid effects on freshwater essential fish habitat. Although unavoidable impacts will occur to some freshwater habitat in the NPR-A, those streams and rivers with freshwater essential fish habitat are much less likely to experience those impacts. For example, all streams and rivers currently considered freshwater essential fish habitat (Table D-2 above) are provided an additional safeguard through infrastructure setbacks included in Lease Stipulation/Best Management Practice K-1. Also, since streams and rivers comprising freshwater essential fish habitat are listed within the Anadromous Waters Catalog, they are granted further regulatory protection under the Anadromous Fish Act (AS 16.05.871) which requires additional review and permitting of activities by Alaska Department of Fish and Game. Based on these considerations, oil and gas exploration and development in the NPR-A is assigned the essential fish habitat assessment determination: May affect, not likely to adversely affect.

Appendix E: Common, Scientific and Iñupiaq Names of Species Listed in the IAP/EIS

Table E–1. Common, scientific and Iñupiaq names of species listed in this document

Common name	Scientific name	Iñupiaq name[1]
VEGETATION		
Small trees and shrubs		
Alpine blueberry	*Vaccinium uliginosum*	Subaq/asriavik/asiaq/asiavik
Cloudberry	*Rubus chamaemorus*	Aqpik
Crowberry	*Empetrum nigrum*	Paunbaq
Dwarf birch	*Betula nana* ssp. *exilis*	—
Lapland cassiope	*Cassiope tetragona*	Ikubutigiksut
Lingonberry	*Vaccinium vitis-idaea*	Kikmieeaq/kipmifnaq
Northern Labrador tea	*Ledum palustre ssp. decumbens*	Tilaaqiaq
Mountain alder	*Alnus viridis* ssp. *crispa*	—
Grasses		
(unknown)	*Poa lanata*	—
Alkali grass	*Puccinellia phryganodes*	—
Alaska bluegrass	*Poa hartzii ssp. alaskana*	—
Pendent grass	*Arctophila fulva*	—
Polar grass	*Arctagrostis latifolia*	—
False semaphoregrass	*Pleuropogon sabinei*	—
Eurasian Junegrass	*Koeleria asiatica*	
Tufted hairgrass	*Deschampsia ceaspitosa*	—
Sedges		
Cottongrass	*Eriophorum angustifolium*	—
Cottongrass	*Eriophorum russeolum*	—
Tussock cottongrass	*Eriophorum vaginatum L.*	Maniq
Water sedge	*Carex aquatilis*	—
Wildflowers		
Fewflower draba	*Draba pauciflora*	—
Drummond's bluebell	*Mertensia drummondii*	—
Fireweed	*Epilobium latifolium*	Quppiqutaq
Marsh fivefinger	*Potentilla palustris*	—
Marsh marigold	*Caltha palustris*	—
Pygmy aster	*Aster pygemaeus*	—
Scurvy grass	*Cochlearia officianalis*	—
Stipulated cinquefoil	*Potentilla stipularis*	—
Sweet coltsfoot	*Petasites frigidus*	—

Table E–1. Common, scientific and Iñupiaq names of species listed in this document

Common name	Scientific name	Iñupiaq name[1]
FISH		
Freshwater species		
Alaska blackfish	*Dallia pectoralis*	Iłuuqiniq
Arctic char	*Salvelinus alpinus*	—
Arctic grayling	*Thymallus arcticus*	Sulukpaugaq
Burbot	*Lota lota*	Tittaaliq
Lake trout	*Salvelinus namaycush*	Iqaluaqpak
Longnose sucker	*Catostomus catostomus*	Milugiaq
Ninespine stickleback	*Pungitius pungitius*	Kakalisaauraq
Northern pike	*Esox lucius*	Siulik
Round whitefish	*Prosopium cylindraceum*	Savigunnaq
Slimy sculpin	*Cottus cognatus*	Kanayuq
Threespine stickleback	*Gasterosteus aculatus*	—
Anadromous species		
Arctic cisco	*Coregonus autumnalis*	Qaataq
Arctic lamprey	*Lampetra japonica*	Nimigiaq
Bering cisco	*Coregonus laurettae*	Tiipuq
Chinook (king) salmon	*Oncorhynchus tschawytscha*	—
Chum salmon	*Oncorhynchus keta*	Iqalugruaq
Pink salmon	*Oncorhynchus gorbuscha*	Amaqtuuq
Rainbow smelt	*Osmerus mordax*	Iłhauġniq
Sockeye (red) salmon	*Oncorhynchus nerka*	—
Amphidromous species[2]		
Broad whitefish	*Coregonus nasus*	Aanaaqłiq
Dolly varden	*Salvelinus malma*	Iqalukpik
Humpback whitefish	*Coregonus pidschian*	Piquktuuq
Least cisco	*Coregonus sardinella*	Iqalusaaq
Marine species[3]		
Arctic cod	*Boregogadus saida*	Uugaq
Arctic flounder	*Liopsetta glacialis*	Nataaġnaq/Puyyagiaq
Capelin	*Mallotus villosus*	Panmigriq
Fourhorn sculpin	*Myoxocephalus quadricornus*	Kanayuq
Kelp snailfish	*Liparis tunicatus*	—
Pacific herring	*Clupea harengus*	Uqsruqtuuq
Pacific sandlance	*Ammodytes hexapterus*	—
Saffron cod	*Eleginus gracilis*	Uugaq
Arctic cod	*Boregogadus saida*	Uugaq

Table E–1. Common, scientific and Iñupiaq names of species listed in this document

Common name	Scientific name	Iñupiaq name[1]
BIRDS		
Seabirds		
Arctic tern	*Sterna paradisea*	Mitqutailxaq
Black guillemot	*Cepphus grylle*	Ifabiq
Glaucous gull	*Larus hyperboreus*	Nauyavasrugruk
Long-tailed jaeger	*Stercorarius longicaudus*	Isuffaq
Parasitic jaeger	*Stercorarius parasiticus*	Mibiaqsaayuk
Pomarine jaeger	*Stercorarius pomarinus*	Isuffabluk
Sabine's gull	*Xema sabini*	Aqargigiaq
Loons		
Pacific loon	*Gavia pacifica*	Malbi
Red-throated loon	*Gavia stellata*	Qaksrauq
Yellow-billed loon	*Gavia adamsii*	Tuutlik
Waterfowl		
Brant	*Branta nigricans*	Niblinbaq
Canada goose	*Branta canadensis*	Iqsrabutilik
Common eider	*Somateria mollissima*	Amauligruaq
King eider	*Somateria spectabilis*	Qifalik
Lesser snow goose	*Anser caerulescens caerulescens*	—
Long-tailed duck	*Clangula hyemalis*	Aahaaliq
Northern pintail	*Anas acuta*	Kurugaq
Scaup	*Aythya* spp.	—
Scoter	*Melanitta* spp.	—
Spectacled eider	*Somateria fischeri*	Qavaasuk
Steller's eider	*Polysticta stelleri*	Igniqauqtuq
Tundra swan	*Cygnus columbianus*	—
White-fronted goose	*Anser albifrons*	Kigiyuk/niblivaixuk
Shorebirds		
American golden-plover	*Pluvialis dominica*	Tullik
Baird's sandpiper	*Erolia bairdii*	Puviaqtuuyaaq
Bar-tailed godwit	*Limosa lapponica*	Turraaturaq
Black-bellied plover	*Squatarola squatarola*	Tullikpak
Buff-breasted sandpiper	*Tryngites subruficollis*	Satqagiixaq
Dunlin	*Erolia alpina*	Siiyukpaligauraq
Long-billed dowitcher	*Linnodromus scolopaceus*	Siiyukpalik
Pectoral sandpiper	*Erolia melanotos*	Puviaqtuuq
Red phalarope	*Phalaropus fulicarius*	Auksruaq
Red-necked phalarope	*Phalaropus lobatus*	—

Table E–1. Common, scientific and Iñupiaq names of species listed in this document

Common name	Scientific name	Iñupiaq name[1]
Ruddy turnstone	*Arenaria interpres*	Tullignaq
Semipalmated sandpiper	*Ereunetes pusillus*	Livilivillakpak
Stilt sandpiper	*Micropalama griseus*	—
Raptors		
Bald eagle	*Haliaeetus leucocephalus*	Tifmiaqpak
Gyrfalcon	*Falco rusticolus*	—
Northern harrier	*Circus cyaneus*	Papiktuuq
Peregrine falcon	*Falco peregrinus*	Kirgavik
Rough-legged hawk	*Buteo lagapus*	Qixbiq
Short-eared owl	*Asio flammeus*	Nipaiouktaq/nipaixuktaq
Snowy owl	*Nyctea scandiaca*	Ukpik
Ptarmigan		
Willow ptamigan	*Lagopus lagopus*	—
Rock ptarmigan	*Lagopus mutus*	Niqsaaqtufiq
Passerine		
Common raven	*Corvus corax*	Tulugaq
Lapand longspur	*Calcarius lapponicus*	Qupajuk/putukiijuk
Redpoll	*Acanthis* spp.	Saqsakiq
Savannah sparrow	*Passerculus sandwichensis*	Aanaruie suliuqpa
Snow bunting	*Plectrophenax nivalis*	Amautligaq/avatalibuuvaq/ amautlikkauraq/amaujigaaluk
MAMMALS		
Large Mammals		
Arctic fox	*Alopex lagopus*	Qusrhaaq/tibiganniaq/qujhaaq
Caribou	*Rangifer tarandus*	Tuttu
Dall sheep	*Ovis dalli dalli*	Imnaiq/ipnaiq
Gray wolf	*Canis lupus*	Amabuq
Grizzly (brown) bear	*Ursus arctos*	Akjaq
Lynx	*Lynx canadensis*	Niutuuyiq/niutuiyiq/nuutuuyiq
Moose	*Alces alces*	Tiniikaq/tuttuvak/tiniika
Muskox	*Ovibos moschatus*	Umifmak/imummak
Red fox	*Vulpes vulpes*	Kavviaq/kayuqtuq
Wolverine	*Gulo gulo*	Qavvik/qapvik
Small Mammals		
Arctic ground squirrel	*Spermophilus parryii*	Siksrik
Barrenground shrew	*Sorex ugyunak*	—
Brown lemming	*Lemmus trimucronatus*	Aviffaq

Table E–1. Common, scientific and Iñupiaq names of species listed in this document

Common name	Scientific name	Iñupiaq name[1]
Collared lemming	*Dicrostonyx groenlandicus*	Qixafmiutauraq
Ermine (short-tailed weasel)	*Mustela erminea*	Itibiaq/tibiaq
Least weasel	*Mustela nivalis*	—
Northern red-backed vole	*Clethrionomys rutilus*	—
Singing vole	*Microtus miurus*	Avieeaq
Snowshoe hare	*Lepus americanus*	Ukalliuraq/ukalliq
Tundra shrew	*Sorex tundrensis*	Ugrufnaq
Tundra vole	*Microtus oeconomus*	Avieeaq
Other mammals		
Coyote	*Canis latrans*	Amabuuraq
Mink	*Mustela vison*	Tibiaqpak
Porcupine	*Erethizon dorsatum*	Ixuqutaq/qifabluk
River otter	*Lutra canadensis*	Pamiuqtuuq
Marine mammals		
Bearded seal	*Erignathus barbatus*	Ugruk
Beluga whale	*Delphinapterus leucas*	Sisuaq/kilalugak
Bowhead whale	*Balaena mysticetus*	Abviq
Polar bear	*Ursus maritimus*	Nanuq
Ringed seal	*Phoca hispida*	Qaibulik/qaibutlik
Spotted seal	*Phoca largha*	Qasigiaq

1. Iñupiaq names from website edition of Iñupiat Eskimo Dictionary: [http://www.alaskool.org/language/dictionaries/inupiaq/dictionary.htm; accessed on April 22, 2004].
2. Have some components of their populations that remain in fresh water year-round.
3. Principal (most commonly caught) coastal fish only.

Appendix F: BLM Sensitive Species List for Alaska

Table F–1. Scientific and common names of BLM Sensitive Species in Alaska

BLM-Alaska sensitive animals		
	Scientific name	**Common name**
Birds	*Gavia adamsii*	Yellow-billed loon*
	Cygnus buccinator	Trumpeter swan
	Chen canagica	Emperor goose
	Branta canadensis occidentalis	Dusky Canada goose
	Aquila chrysaetos	Golden eagle
	Numenius tahitiensis	Bristle-thighed curlew
	Calidris canutus	Red knot
	Calidris ptilocnemis tschuktschor	Bering Sea rock sandpiper
	Brachyramphus brevirostris	Kittlitz's murrelet
	Brachyramphus marmoratus	Marbled murrelet
	Asio flammeus	Short-eared Owl
	Contopus cooperi	Olive-sided flycatcher
	Dendroica striata	Blackpoll warbler
	Euphagus carolinus	Rusty blackbird
	Plectrophenax hyperboreus	McKay's bunting
Mammals	*Lepus othus*	Alaskan hare
	Spermophilus parryii osgoodi	Osgood's arctic ground squirrel
	Sorex yukonicus	Alaskan tiny shrew
	Mustela americana kenaiensis	Kenai marten
	Odobenus rosmarus divergens	Pacific walrus*
	Erignathus barbatus	Bearded seal*
	Phoca hispida hispida	Ringed seal*
Fish	*Lampetra alaskensis*	Alaskan brook lamprey
	Salvelinus alpinus	Arctic char (Kigluaik Mountains)
Insects	*Acentrella feropagus*	A mayfly
	Rhithrogena ingalik	Alaska endemic mayfly
	Alaskaperla ovibovis	Alaska Sallfly

BLM-Alaska sensitive plants	
Scientific name	**Common name**
Antennaria densifolia	
Arnica lonchophylla	Northern arnica
Artemisia globularia ssp. *lutea*	
Artemisia laciniata	Siberian wormwood
Artemisia senjavinensis	Arctic sage
Aster pygmaeus (Eurybia pygmaea)	Pygmy aster
Botrychium ascendens	Moonwort
Carex adelostoma	Circumpolar sedge
Claytonia arctica	Arctic springbeauty

Table F–1. Scientific and common names of BLM Sensitive Species in Alaska

Claytonia ogilviensis	Ogilvie Mountains spring beauty
Cryptantha shackletteana	Shacklettes' catseye
Douglasia alaskana	Alaska rock-jasmine
Douglasia arctica	Mackenzie River Douglasia
Douglasia beringensis	Arctic dwarf primrose
Draba micropetala	Alpine Whitlow-grass
Draba murrayi	Murray's Whitlow-grass
Draba ogilviensis	
Draba pauciflora	Adam's Whitlow-grass
Erigeron muirii	Muir's fleabane
Erigeron yukonensis	
Eriogonum flavum var. *aquilinum*	Yukon wild-buckwheat
Erysimum asperum var. *angustatum*	A wallflower
Gentianopsis detonsa ssp. *detonsa*	Sheared gentian
Koeleria asiatica	Oriental Junegrass
Lesquerella calderi	Calder's bladderpod
Mertensia drummondii	Drummond's bluebell
Montia bostockii	Bostock's miner's-lettuce
Oxytropis arctica var. *barnebyana*	Barneby's locoweed
Oxytropis huddelsonii	
Oxytropis kobukensis	Kobuk locoweed
Papaver alboroseum	Pale poppy
Papaver gorodkovii	
Papaver walpolei	Walpole poppy
Parrya nauruaq	
Pedicularis hirsuta	
Phacelia mollis	Macbride phacelia
Pleuropogon sabinei	Sabine-grass
Poa hartzii ssp. *alaskana*	
Poa porsildii	
Potentilla stipularis	Circumpolar cinquefoil
Primula tschuktschorum	Chukchi primrose
Puccinellia wrightii	
Ranunculus camissonis	
Ranunculus glacialis var. *L*	
Ranunculus turneri	Turner's butter-cup
Rumex graminifolius	
Rumex krausei	Cape Krause sorrel
Smelowskia johnsonii	
Smelowskia pyriformis	
Trisetum sibiricum ssp. *litorale*	Siberian false-oats

* Species that have been designated as candidate or proposed for listing under the Endangered Species Act. These species are automatically included on the BLM-Alaska Sensitive Species list at least until the candidate or proposed status is removed.

Appendix G: Information, Models, and the Assumptions Used to Analyze the Effects of Oil and Saline Spills and Gas Releases

This IAP/EIS analyzes oil and saline spills and gas releases, and their potential impacts to environmental, economic, and sociocultural resources and resource areas, which could result from oil exploration and development and production in the National Petroleum Reserve – Alaska (NPR-A). Estimating a future oil or saline spill or gas release is an exercise in probability. There is uncertainty associated with the location, timing, number, and volume of spills or releases, the chemical and physical properties of the spill or release, and the environmental conditions at the time of a spill or release. Although some of the uncertainty reflects imperfect data, there is also a considerable amount of uncertainty involved in estimating accidental spills and releases 15 to 90 years into the future. Section G1 and G2 discuss oil and saline spills, section G3 discusses gas releases and section G3 discusses the cumulative analysis.

This first section explains the data, methods, and results of an analysis of historical crude oil, refined product (“product”)and saline spills for the Alaska North Slope, including wells, facilities and other pipelines up to (but not including) Pump Station 1 (PS-1). PS-1 marks the beginning of the Trans-Alaska Pipeline System and is included in the Trans-Alaska Pipeline analysis. The purpose of this spill analysis is to estimate the potential spill rates. The rates are used to estimate the potential crude, refined oil and saline spills. The spill estimates are then used to analyze the direct and indirect environmental impacts of the exploration and development and production within NPR-A.

The spill rate estimation method is based on statistical models used by the Bureau of Ocean Energy Management for Alaska North Slope and other oilfields. The data used for this analysis include historical Alaska North Slope crude and refined oil spills. The basic assumption is that the likelihood of future crude and refined oil and saline spills associated with the NPR-A exploration and production and development can be estimated from prior Alaska North Slope experience. It is assumed that spill rates (per billion barrels produced) for NPR-A will be similar to those at other Alaska North Slope facilities.

Estimates about oil and saline spills are used to create a scenario to analyze their effects to environmental, economic, and sociocultural resources and resource areas. These estimates pertain to the type of spill, the source of a spill, the general location and size of a spill, the chemistry of the oil, how the oil will weather, how long the oil will remain, and where the oil will go. Project-specific information, statistical analysis, and professional judgment support these assumptions. Based on these estimates, a scenario is created to reflect the spill information used for analysis, and the effects of such spills are analyzed. These steps constitute a “what if a spill occurs” analysis.

This spill analysis considers the entire exploration and development/production life of the NPR-A area, and assumes that commercial quantities of hydrocarbons are present in the planning area and that these hydrocarbons will be developed and produced at the estimated resource levels presented in the IAP/EIS. Uncertainties exist, such as 1) the actual resource levels, 2) the actual size of a crude, refined oil spill or saline spill, 3) the approximate location of oil assumed to be produced, and 4) whether production would occur at all. If no hydrocarbons exist, there is no chance of a crude oil or saline spill occurring in the planning area.

G.1 Oil and Saline Spill Size Categories

This IAP/EIS analyzes what is likely to happen in the future, using estimates about the likely size, duration, and type of a spill to analyze the effects. To estimate these parameters, spills are divided into three types: crude oil, refined oil and saline spills. Crude oil spills are divided into three size categories: small, large, and very large. Within each of these categories, generalized and specific estimates are made. Refined oil spills fall into the small spill size category. Saline spills are analyzed for large spills.

Small spills are defined as those less than 500 barrels (bbl; 1 bbl = 42 gallons); large spills are greater than or equal to 500 bbl or 1,000 bbl (depending upon the data source); and very large spills are greater than or equal to 120,000 bbl. Table G-1 shows the assumed source of a spill(s), type of fluid, size of spill(s) in bbl, and the receiving environment that is assumed in the analysis of the effects of oil spills in this IAP. The effects of spill(s) are analyzed in Chapter 4 (Environmental Consequences; Volumes 2 and 3). The following sections discuss the oil and saline spill analysis, and the assumptions used for effects analysis, for each of these three size categories.

Table G–1. Spill scenario for the alternatives

Source of spill	Type of oil	Size of spill (bbl)	Assumed number of spills under each alternative				Receiving environment
			A	B	C	D	
Small oil spills (< 500 bbl) onshore or NPR-A offshore waters							
Operational spills from all sources	Crude	3	135	94	132	142	Ice, tundra, snow, gravel pad, and water
	Refined	0.8	390	273	382	411	
Large oil spills (≥ 500 bbl) onshore or NPR-A offshore waters							
Pipeline	Crude	5,100	1	1	1	1	Ice, tundra, snow, gravel pad, and water
Facility/ Storage Tank/ gravel pad	Crude	900					
All	Saline	1,900	1	1	1	1	
Very large oil spills (≥ 120,000 bbl) onshore or NPR-A offshore waters							
Well control incident/long duration flow	Crude	120,000	NA	NA	NA	NA	Ice, tundra, snow, gravel pad, and water

G.1.1 Large Crude Oil Spills- Greater Than or Equal to 500 Barrels

Large spills are defined as greater than or equal to 500 barrels for the Alaska North Slope onshore and state waters and Trans-Alaska Pipeline System and greater than or equal to 1,000 bbl for the Outer Continental Shelf. Historical information about previous large spills on the Alaska North Slope and from the Trans-Alaska Pipeline System was used to estimate the hypothetical size of large spills and the rate at which such large spills would be estimated to occur in the future from leasing, exploration and development and production within NPR-A.

G.1.1.1 Historical Large Crude Oil Spill Sizes

Large spills are defined as greater than or equal to 500 barrels for the Alaska North Slope onshore and state waters and the Trans-Alaska Pipeline System. Historical information about large spills oil and gas condensate spills on the Alaska North Slope and from the Trans-Alaska Pipeline System was used to estimate the hypothetical size of large spills. Large spill occurrence rates in terms of number of spills per billion barrels produced were also estimated. Estimates for large spills from production in the NPR-A area are based on the historic large spill rates and sizes from onshore Alaska North Slope oil industry spills from 1985 to 2010 for large crude oil spills, and the Trans-Alaska Pipeline System pipeline spills from 1977 to 2010.

Historical Alaska North Slope Crude Oil Spills (Greater Than or Equal to 500 Barrels)

The Alaska North Slope large oil spill analysis includes onshore oil and gas exploration and development spills from the Point Thomson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, Colville River, Bear Tooth, Greater Mooses Tooth and offshore Duck Island Unit (Endicott), Oooguruk, Nakaitchuq and Northstar Unit. Alaska North Slope spill data include large spills from onshore pipelines and offshore state waters and onshore production and gathering facilities. The following information does not include spills on the Alaska North Slope from the Trans-Alaska Pipeline System, which were evaluated separately.

For the Alaska North Slope, all available information on historic industry oil spills greater than or equal to 100 barrels during the period 1968 through 2000 was obtained from industry and regulatory agencies and collated (Hart Crowser, Inc. 2000). The USDOI Minerals Management Service (now Bureau of Ocean Energy Management) and Hart Crowser, Inc. collected data for crude oil spills for the U.S. Beaufort Sea, the NPR-A, and Onshore Alaska North Slope east of the NPR-A from the oil and gas industry, State of Alaska, Department of Environmental Conservation, USDOI, BLM and Minerals Management Service, Alyeska Pipeline Services Co., Joint Pipeline Office and Oil Spill Intelligence report.

A review of the reliability and completeness of the data for spills greater than or equal to 500 bbl (Hart Crowser, Inc. 2000) indicated that the available information was most reliable starting in1985 for crude oil spills on the Alaska North Slope, based on written documentation or lack of documentation for spills before that period. The Bureau of Ocean Energy Management determined that spills greater than or equal to 100 barrels were documented and included in the database since 1985. In 1985, the Alaska Department of Environmental Conservation began tracking spills in an electronic format. Although Hart Crowser, Inc. (2000) states that the database is complete for the years since production began, the BLM prefers to use 1985 as the starting point of reliability for large spills and 1989 for small spills

Analysis of the spill databases indicates that there are fewer spill records per year in the early years of Alaska North Slope production (Everest Consulting Associates 2007). The average number of spills reported from 1977 to 1984 was 100 per year. The average number of spills reported from 1985 to 2006 was 324 spills per year—greater by a factor of three. Any uncertainty in documenting spills before that time is a concern because it is typical for spills to occur more frequently during field and pipeline startup.

Eight crude oil spills greater than or equal to 500 barrels associated with onshore and nearshore Alaska North Slope oil production occurred from 1985 to 2010 (Table G-2). One spill greater than or equal to 1,000 barrels was documented during this time period. Of the eight spills, three are classified as a pipeline spill. Four are classified as production processing and one as a production well site. These five spills collectively are called facility spills.

Table G–2. Alaska North Slope facility and pipeline crude oil spills 1985-2010 (greater than or equal to 500 barrels)

Spill date	Facility type	Facility operator	Oil type	Spill location	Spill cause	Low spill quantity (barrels)	High spill quantity (barrels)
28-Jul-89	Production Processing	Conoco, Inc.	Crude Oil	Milne Point Unit, Central Processing Facility	Facility Tank Leak–overfill	825	925
25-Aug-89	Pipeline	ARCO Alaska, Inc.	Crude Oil	Kuparuk River Unit, Drill Site 2-U	Pipeline Leak–corrosion of block valve	340[2]	603[2]
10-Dec-90	Production Well Site	ARCO Alaska, Inc.	Crude Oil	Lisburne Unit, Drill Site L-5	Facility Explosion	176[1]	600[1]
17-Aug-93	Production Processing	ARCO Alaska, Inc.	Crude Oil/ Produced Water	Kuparuk River Unit CPF 1	Tank Leak–Corrosion		675
26-Sep-93	Production Processing	BP Exploration (Alaska)	Crude Oil	Prudhoe Bay Unit, Gathering Center 2	Facility Tank Leak– overflow due to pump failure		650
21-Aug-00	Production Processing	BP Exploration (Alaska)	Crude Oil/ Produced Water	Prudhoe Bay Unit, Gathering Center 2	Facility Tank Leak– overflow due to control system failure	700	715[4]
19-Feb 01	Pipeline	BP Exploration (Alaska)	Crude Oil/	West Prudhoe Bay, between D-pad and gathering center	Pipeline Leak – Line Failure, Human Error	225[4]	608.33[2]
02-Mar-06	Pipeline	BP Exploration (Alaska)		Prudhoe Bay Unit, GC-2 34” Oil Transit Line	Pipeline Leak - Corrosion		5053.62[3]

Sources: 1. Hart Crowser (2000); 2. Alaska Department of Environmental Conservation; 3. Unified Command ;4. BPXA

Using the highest reported spill-quantity values, from 1985 to 2010, the median spill size for facilities and pipeline greater than or equal to 500 barrels on the Alaska North Slope was 663 barrels, and the mean (or average) was 1,229 barrels. For purposes of analysis, the BLM uses the largest spill sizes of record. The largest facility spill on record is 925 barrels. The largest pipeline spill is 5,053 barrels. Rounded to the nearest 100 barrels (to reflect the uncertainty associated with spill estimates), the hypothetical spill sizes used for purposes of analysis are 900 barrels for the facility spill and 5,100 barrels for the pipeline spill.

Historical Trans-Alaska Pipeline Crude Oil Spills (Greater Than or Equal to 500 Barrels)

Private industry provides oil-spill information to the State Department of Environmental Conservation according to the State of Alaska Regulations (18 AAC 75) and the U.S. Department of Transportation according to 49 CFR 195.50 (Reporting Accidents). The Trans-Alaska Pipeline spill data were compiled by Hart Crowser, Inc. (2000) Maxim and Niebo (2002) and National Research Council (2003). The oil-spill data were collated and evaluated for completeness and comprehensiveness. The Alaska Department of Environmental Conservation, U.S. Department of Transportation, and Alyeska spill data reports were used to update the Trans-Alaska Pipeline crude large oil spill data to 2010.

The Trans-Alaska Pipeline spill data include the pipeline from the Alaska North Slope to the Valdez marine terminal. It does not include oil spills at the marine terminal. The Trans-Alaska Pipeline oil-spill analysis includes the pipeline and the pump stations, but excludes the Valdez marine terminal. Nine crude oil spills greater than or equal to 500 barrels associated with the Trans-Alaska Pipeline System occurred from 1977 through 2010 (Table G-3). Most large crude oil spills were associated with the start-up of the pipeline. No large spills greater than or equal to 1,000 barrels occurred from 1981 to October 2001; a period of 20 years. The mean (average) size crude oil spill greater than or equal to 500 barrels from 1977 to 2001 is 5,141 barrels, and the median is 4,000 barrels. For spill analysis, the median spill quantity is used and rounded to the nearest 100. Therefore, the median hypothetical Trans-Alaska Pipeline System pipeline spill size is 4,000 barrels for the cumulative oil spill analysis.

Historical and Statistical Alaska North Slope Blowout Information

The record for Alaska North Slope well control incidents is not validated, but is presented as the best available information. There are three written reports regarding well control incidents or blowouts on the Alaska North Slope: Mallory (1998), Fairweather (2000) and National Research Council (2003). Fairweather (2000) found 10 blowouts—six that Mallory had identified for the period 1974 to 1998 and four that occurred before 1974.

On February 15, 2012 Repsol had a loss of well control from an exploration well on the Qugruk #2 pad (Q2 pad), on the Colville River Delta, approximately 18 miles northeast of Nuiqsut and approximately 150 miles southeast of Barrow (70° 27' 19" N, 150° 44' 52" W). The loss of well control from a shallow gas pocket released an unknown quantity of gas and approximately 42,000 gallons (1,000 bbls) of drilling mud. The well ceased flowing on February 16, 2012.

Of the 11 blowouts, 10 were gas and 1 was oil. The 1950 oil blowout was unspectacular and could not have been avoided, as there were no casings or blowout preventers available (Fairweather 2000). Drilling practices from 1950 would not be relevant today.

A third study confirmed that no crude oil spills greater than or equal to 100 bbl from blowouts occurred from 1985 through 1999 (Hart Crowser, Inc. 2000). A report titled Blowout Frequency Assessment of Northstar (Scandpower AS 2001) uses statistical blowout frequencies modified to reflect specific field conditions and operative systems at Northstar. This report concludes that the blowout frequency for drilling in the oil-bearing zone at Northstar is 1.5×10^{-5} per well drilled. In comparison, the average statistical blowout frequency for a development well in the North Sea and U.S. Gulf of Mexico is 7.4×10^{-5} per well. This same report estimates that the statistical frequency of a blowout spill with a size greater than 130,000 barrels is 9.4×10^{-5} per well drilled for Northstar.

Table G–3. The Trans-Alaska Pipeline crude oil spills 1977-2010 (greater than or equal to 500 barrels)

Spill date	Facility type	Facility operator	Spill name	Spill location	Spill cause	Low spill quantity (barrels)	High spill quantity (barrels)	Quantity used in analysis
08-Jul-77	Pipeline Pump Station	Alyeska Pipeline Service Co.	Pump Station 8	TAPS PS 8 (TAPS MP 489.2)	Facility Explosion [a,b, c] Unspecified [e]	300 [b]	4,762 [b] 300 [a,c,e]	4,762 [b]
19-Jul-77	Pipeline	Alyeska Pipeline Service Co.	Check Valve 7	TAPS MP 26 (Check Valve 7)	Pipeline Leak - equipment damage [a,b, c] Human Error [e]	1000 [a,b]	1,800 [a] 1,000 [c,e] 2,620 [2]	1,800 [a]
15-Feb-78	Pipeline	Alyeska Pipeline Service Co.	Steele Creek	TAPS MP 457	Pipeline Leak - intentional sabotage [a,c] Unspecified [5]	11,905 [a]	16,000 [a] 11,905 [c,e]	16,000 [a]
10-Jun-79	Pipeline	Alyeska Pipeline Service Co.	Atigun Pass	TAPS MP 166 (N. side of Atigun Pass)	Pipeline Leak - line break [a,b,c,e]	1,500 [b]	7,143 [b] 1,500 [a,e] 5,267 [c]	7,143 [b]
15-Jun-79	Pipeline	Alyeska Pipeline Service Co.	Little Tonsina	TAPS MP 734	Pipeline Leak - line break [a,b,c,e]	300 [b]	4000 [a,b] 300 [c,e]	4,000 [a,b]
01-Jan-81	Pipeline	Alyeska Pipeline Service Co.	Check Valve 23	TAPS MP 114.6 (Check Valve 23)	Pipeline Leak - leaking valve	1,000 [b]	1,500 [a,c,d,e] 2,000 [f] 2,381 [b]	2,381 [b]
20-Apr-96	Pipeline	Alyeska Pipeline Service Co.	Check Valve 92	TAPS MP 539.7 (Check Valve 92)	Pipeline Leak - loose fitting	800 [a,b]	811 [a]	811 [a]
4-Oct-01	Pipeline	Alyeska Pipeline Service Co.		TAPS MP 400	Pipeline Leak -intentional sabotage - bullet hole	6,800	6,800	6,800
12-May-10	Tank	Alyeska Pipeline Service Co.	Pump Station 9, Tank 190		Tank Leak - Circuit Failure Valve Control	NA	2580 [a,b]	2580 [a,b]

Sources: a. Alyeska Pipeline Service Company; b. Alaska Department of Environmental Conservation; c. Unknown; d. Bureau of Land Management; e. Joint Pipeline Office; f. Oil Spill Intelligence Report

However unlikely a well control incident resulting in a long duration flow may be, it is an important concern to the public; therefore, the effects of a 120,000 barrels (15-day) spill are analyzed in section 4.12 in Volume 4 (“Low Probability, Very Large Oil Spill”).

G.1.1.2 Historical Alaska North Slope and Trans Alaska Pipeline Large Crude Oil Spill Rates

To use historical Alaska North Slope industry spill records to successfully estimate the chance of one or more large oil spills occurring, there must be a properly developed and validated database. Ideally, the database should include a wide range of spill volumes over a long period of time from oil exploration and production resembling the prospective project.

The record of Alaska North Slope onshore and state waters large crude oil spills from 1985–2010 represents a long time period and the record of large spills have been validated through several past and ongoing studies (Hart Crowser 2000, Maxim and Niebo 2002, National Research Council 2003, Everest Consulting 2006, Nuka 2010).

In addition to a properly developed and validated database, the computation of an oil-spill rate requires an exposure variable. The purpose of an exposure variable is to balance equally different oil developments that should have similar oil spill frequencies for a given size of spills. Such an exposure variable is required, because oil developments rarely exactly resemble one other. Two basic criteria for the selection of an exposure variable are: (1) it should be defined simply; and (2) it should be a quantity readily estimated. The verification of a potential exposure variable includes a demonstration that the exposure variable generates equal values, in a statistical sense, for oil developments with similar oil-spill histories.

For oil spills, numerous such variables are in use, including historic volumes of oil produced/transported, number of wells drilled, well-years, and pipeline mile-years. Each of these exposure variables has an assigned application; for example, "wells drilled" would be used to compute the chance of a well control incident during drilling operations. Moreover, two different variables may be used for computing the spill rate from the same segment of an oil development; for example, both historic volumes of oil produced/transported, and pipeline mile-years are used to estimate the spill rate from the same pipeline. For this analysis, the exposure variable of volume of oil produced and pipeline mile year were calculated. For purposes of analysis, volume of oil produced was used to estimate the large spill rate.

Alaska North Slope Production		**Trans-Alaska Pipeline Mileage**	
1977-2010	16.28 billion barrels	1977-2010	26,838 pipeline mile years
1985-2010	12.40 billion barrels	1985-2010	20,808 pipeline mile years

Alaska North Slope Large Crude Oil Spill Rate 1985-2010 Based on Volume

Since 1985, one Alaska North Slope facility or pipeline spill greater than or equal to 1,000 barrels from Alaska North Slope production has occurred. No documentation for crude oil spills greater than or equal to 100 barrels occurring prior to 1985 was found, but spill records dated prior to 1985 have not been validated as complete because of missing or incomplete documentation (Hart Crowser 2000).

As noted above, eight large spills are documented from 1985 to 2010. For that same time period the total Alaska North Slope production was 12.40 billion barrels of crude oil and condensate (Alyeska Pipeline Service Company 2011). The Alaska North Slope spill rates for crude oil spills greater than or equal to 500 barrels from 1985-2010 are:

- 0.65 total spills per billion barrels of oil produced,
- 0.41 facility spills per billion barrels of oil produced, and
- 0.24 pipeline spills per billion barrels of oil produced.

Trans-Alaska Pipeline Large Crude Oil Spill Rate 1977-2010 and 1985-2010 Based on Volume and Pipeline-Mile-Year

Flow in the Trans-Alaska Pipeline System began on June 20, 1977, with throughput of 112 million barrels by the end of 1977. Throughput increased to almost 400 million barrels in 1978, peaked at 744 million barrels in 1988, and was 226 million barrels in 2010. The estimated total volume transported through the Trans-Alaska Pipeline System during the period 1977 through 2010 is 16.28 billion barrels condensate (Alyeska Pipeline Service Company 2011). The Trans-Alaska Pipeline System is 800.302 miles long.

1977-2010

There have been nine crude oil spills greater than or equal to 500 barrels attributed to Trans-Alaska Pipeline System operation, eight of which were greater than or equal to 1,000 barrels. The last spill greater than or equal to 1,000 barrels occurred in 2010 at Pump Station 9. The spill rate of 0.55 spills for spills greater than or equal to 500 barrels of spills per billion barrels transported for Trans-Alaska Pipeline System pipeline was calculated based on the record of seven accidental and two sabotage spills over 16.28 billion barrels of production. The spill rate of 0.0003354 large spills per pipeline-mile-year for the Trans-Alaska Pipeline System was calculated based on the record of seven accidental and two sabotage spills over 26,638 pipeline-mile-years during the period 1977 through 2010.

1985-2010

There have been three crude oil spills greater than or equal to 500 barrels, of which two were greater than or equal to 1,000 barrels. The spill rate of 0.24 spills for spills greater than or equal to 500 barrels of spills per billion barrels transported for the Trans-Alaska Pipeline System was calculated based on the record of three accidental spills over 12.40 billion barrels of production. The spill rate of 0.0001442 large spills per pipeline-mile-year for the Trans-Alaska Pipeline System was calculated based on the record of two accidental and one sabotage spill over 20,808 pipeline-mile-years during the period 1985 through 2010.

G.1.1.3 Estimated Mean Number and Percent Chance of One or More Large Crude Oil Spills for the National Petroleum Reserve – Alaska

The mean number of large crude oil spills, estimated over the production life of the planning area for Alternative A, Alternative B-1, Alternative B-2, Alternative C, and Alternative D are shown in Table G-4. The mean number of large spills is derived from the projected resource volumes and the historic large crude spill rate for the Alaska North Slope. For each alternative, the estimated mean spill number is less than one. For purposes of analysis one large spill is assumed for each alternative and it could be either from a facility or a pipeline. The estimated spill size volumes are 900 barrels for a facility spill or 5,100 barrels for a pipeline spill.

The estimated mean number of large spills over the life of exploration and production (listed in Table G-4) is used to estimate the chance of one or more large spills occurring. The estimated chance of one or more large spills occurring ranges from 28 percent for Alternative B-1 to 39 percent for Alternative D over the entire life of production. The estimated chance of no large spills occurring ranges from 72 percent for Alternative B-1 to 61 percent for alternative D over the entire life. It is more likely that no large spills will occur than one or more over the exploration, development and production life of the NPR-A alternatives.

Table G–4. Large crude oil spills estimated over the exploration, development, and production life of the National Petroleum Reserve-Alaska

Alternative	Resources (Bbbl)	Spill rate (spills/Bbbl)	Assumed spill size (bbl)	Estimated mean number of spills[1]	Estimated total spill volume[2] (bbl)	Percent chance of one or more large spills occurring[3]
Crude oil						
A	0.723	0.65	900/5,100	0.47	900 or 5,100	37
B-1	0.505	0.65	900/5,100	0.33	900 or 5,100	28
B-2	0.549	0.65	900/5,100	0.36	900 or 5,100	30
C	0.707	0.65	900/5,100	0.46	900 or 5,100	37
D	0.761	0.65	900/5,100	0.49	900 or 5,100	39

1. The estimated mean number of oil spills is based on the estimated resource volume multiplied by the large spill rate.
2. The estimated total spill volume is the total volume for all of the estimated spills for the given alternative and price of oil.
3. The estimated percent chance over the life of exploration, development and production.

G.1.1.4 Alaska North Slope Large Saline Spills 1995-2009 (Greater than or Equal to 500 barrels)

In 2010, an Alaska North Slope spill analysis focused on oil and gas industry spills (Nuka Research and Planning Group, 2010). The purpose of the study was to analyze spills and determine mitigation to reduce the frequency and severity of future oil spills from Alaska North Slope crude oil piping infrastructure. The analysis focused on the loss-of-integrity spills. Loss-of integrity spills were defined as a failure the leads to a reportable spill of any fluids in the production stream. Because it considered all fluids the results of this study are not directly comparable to the results of crude and refined oil spills discussed above. In general, the study indicated similar trends and patterns as discussed here. The study discussed process/produced and seawater spills (hereafter called saline spills) for the first time in detail in addition to focusing on pipeline crude spills.

Appendix D of the above report lists the summary of Alaska North Slope Loss-of –integrity spills greater than 10,000 gallons from July 1, 1995 through December 2009. With the exception of the GC-2 pipeline, which was a crude oil spill, all spills in Appendix D are saline spills (produced water, process water or seawater). The GC-2 pipeline spill is included in the analysis of crude oil spills and is not included here. There have been 6 saline spills greater than or equal to 500 barrels while producing 5.6 billion barrels from July 1, 1995-December 2009 (Table G-5). The estimated large saline spill rate is 1.1 saline spills/billion barrels produced. Using the six saline spills listed in Table G-5 greater than or equal to 500 barrels, the mean spill size for this time period is 2,363 barrels and the median is 1,850 barrels. For oil spill analysis the median spill size is used and rounded to the nearest 100. Therefore, the median hypothetical large saline spill is 1,900 barrels.

Nuka Research and Planning Group (2010) examined where spills occurred specifically for flowline and oil transmission pipelines from July 1995-December 2009. Flowlines and oil transmission pipelines traverse more area that is not on pad or on road. The results for flowline and oil pipeline spills indicate 35 percent by number spills on tundra and 65 percent on gravel pads. In terms of volume the trend reverses; 78.3 percent by volume spills on tundra and 21.7 percent spills on gravel pads. A total of 5.2 acres were impacted by all loss of integrity spills from July 1995-December 2009. For those spills reaching the tundra 82.1 percent by volume was to frozen tundra and 17.9 percent was to thawed tundra.

Table G–5. Alaska North Slope facility and pipeline saline spills 1995-2009 (greater than or equal to 500 barrels)

Spill date	Oil field	Regulatory category	Fluid spilled (gal)	Spill cause	High spill quantity (barrels)
19-Dec-06	Prudhoe Bay	Above Ground Storage Tank	Produced Water	Mechanical Failure	6,075
25-Dec-08	Kuparuk River	Facility Oil Piping	Produced Water	Corrosion	2,260
15-Apr-01	Kuparuk River	Flowline	Produced Water	External Corrosion	2,200
10-Jan-98	Kuparuk River	Flowline	Produced Water	Material Failure	1,500
3-Nov-08	Prudhoe Bay	Facility Oil Piping	Seawater	Internal Corrosion	1,467
8-Jun-04	Prudhoe Bay	Process Piping	Process Water	Valve or Seal Failure	675

Source: Nuka Research and Planning Group (2010), State of Alaska Department of Environmental Conservation (2011).

The mean number of large saline spills, estimated over the production life of the planning area for Alternatives A, B-1, B-2, C, and D are shown in Table G-6. The mean number of large saline spills is derived from the projected resource volumes and the historic large saline spill rate for the Alaska North Slope. For each alternative, the estimated mean spill number is less than one. For purposes of analysis one large saline spill is assumed for each alternative and it could be either from a process water, three phase flow or a seawater pipeline or a tank. The estimated spill size volume is 1,900 barrels for a pipeline or tank spill.

Table G–6. Large saline spills estimated over the exploration, development, and production life of the National Petroleum Reserve-Alaska

Alternative	Resources (Bbbl)	Spill rate (spills/Bbbl)	Assumed spill size (bbl)	Mean number of spills	Assumed number of spills	Estimated volume in barrels
Crude oil						
A	0.723	1.1	1,900	0.80	1	1,900
B-1	0.505	1.1	1,900	0.56	1	1,900
B-2	0.549	1.1	1,900	0.60	1	1,900
C	0.707	1.1	1,900	0.78	1	1,900
D	0.761	1.1	1,900	0.84	1	1,900

bbl = barrels; Bbbl = billion barrels

G.1.2 Small Crude and Refined Oil Spills - Less Than 500 Barrels

Small oil spills are defined as spills that are less than 500 barrels for the onshore and state waters of the Alaska North Slope. The BLM considers two oil types for small spills: crude oil and refined oil. The BLM expects the same companies to participate onshore in the

National Petroleum Reserve-Alaska as those that are now operating on the onshore and state waters of the Alaska North Slope. The BLM expects similar but not exact environmental conditions. It is reasonable to assume that the small oil spill occurrence rate in the National Petroleum Reserve-Alaska will be similar to the small oil spill occurrence rate on the onshore and state waters of the Alaska North Slope.

Historical small oil spill information and simple statistical methods are used to derive the following information about small crude and refined oil spills that occur on the onshore Alaska North Slope:

- estimates of the number of small spills for every billion barrels of oil produced (oil-spill rates);
- estimates of the spill size distribution of small spills; and
- estimates of the mean and median size of small oil spills from facilities, pipelines, and flow lines combined.

The BLM uses this information to estimate the number, size and distribution of small spills that may occur from leasing and subsequent exploration and development in NPR-A. The analysis of small oil spills considers the entire exploration and development and production life and assumes: (1) commercial quantities of hydrocarbons are present and (2) these hydrocarbons will be developed and produced at the estimated resource levels.

The historical information consists of crude and refined oil spills reported to the Alaska Department of Environmental Conservation and the Joint Pipeline Office by the oil industry, their subcontractors and regulatory entities. Crude and refined oil spill rates and patterns from onshore Alaska North Slope and state waters oil and gas exploration and development activities are determined for spills less than one gallon and less than 500 barrels. Refined oil includes aviation fuel, diesel fuel, engine lubricants, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. The onshore Alaska North Slope oil spill analysis includes onshore and offshore oil and gas exploration and development spills from the Point Thompson Unit, Badami Unit, Kuparuk River Unit, Milne Point Unit, Prudhoe Bay West Operating Area, Prudhoe Bay East Operating Area, Colville River, Bear Tooth, Greater Mooses Tooth and offshore Duck Island Unit (Endicott), Oooguruk, Nakaitchuq and Northstar Unit.

Oil spill information is provided to the Alaska Department of Environmental Conservation in accordance with State of Alaska Regulations (18 AAC § 75). The Alaska Department of Environmental Conservation figures are based on initial spill reports and may or may not contain updated information. Because of increased scrutiny after the Exxon Valdez oil spill, small oil spill, information in the Alaska Department of Environmental Conservation database is most reliable for 1989 and later. Even though the integrity of the database cannot be validated thoroughly, the information in the database is still valuable because it is the only publically available data on Alaska North Slope small spills. A simple analysis of small oil spills was performed, and small spill rates were estimated without regard to differentiating operation processes.

A total small spill rate of 727 spills per billion barrels produced, calculated from the Alaska North Slope record of small spills, is used here. This total small spill rate consists of 187 small crude oil spills per billion barrels and 540 small refined product spills per billion barrels produced as is discussed further below.

G.1.2.1 Historical Small Crude Oil Spill Rates and Patterns on the North Slope

The analysis of crude oil spills was performed collectively for all Alaska North Slope facilities, pipelines, and flow lines for the period 1989-2009. The pattern that emerged was one of numerous small crude oil spills. The number of small crude spills per year ranged from a minimum of 32 to a maximum of 228 and the total volumes ranged from about 40 to 793 barrels in any given year. Of the small crude oil spills that occurred between 1989 and 2009, the Alaska Department of Environmental Conservation database indicates that the majority of spills are less than 1 barrel:

- 16 percent were less than or equal to 1 gallon;
- 54 percent were less than or equal to 5 gallons;
- 82 percent were less than or equal to 1 barrel and
- 98.5 percent were less than 25 barrels.

As with all oil spill distributions; small spills are numerous and collectively add up to a small volume and a few of the small crude spills contribute the majority of the volume.

The individual small crude spill sizes in the database range from less than 1 gallon to 375 barrels. The mean small crude oil spill size on the Alaska North Slope is 2.8 barrels, and the median spill size is 5 gallons (Table G-7). For purposes of the oil spill analysis in this IAP/EIS, a mean small crude oil-spill volume of 3 barrels is assumed.

Table G–7. Small crude-oil spills: Estimated spill rates for the Alaska North Slope

Small crude-oil spills less than 500 barrels, 1989-2009	
Total Volume of Crude Spills	4,872 barrels
Total Number of Spills	1,754 spills
Mean (Average) Spill Size	2.8 barrels
Median Spill Size	5 gallons
Production (Crude Oil)	9.4 billion barrels
Spill Rate	187 spills/billion barrels of crude oil produced

Note: Oil-spill databases are from the Alaska Department of Environmental Conservation, Anchorage, Juneau, and Fairbanks. Alaska North Slope production data are derived from the Trans-Alaska Pipeline System throughput data from Alyeska Pipeline.

The Alaska Department of Environmental Conservation database indicates that the causes of small crude oil spills on the Alaska North Slope. Approximately 7 percent of small crude spills cause in the database are unknown. Causal factors, in decreasing order of frequency include:

- other; which includes individual details of the cause
- leaks
- human error
- seal failures
- unknown
- faulty valves/gauges
- vent discharges
- valve failure
- equipment failure
- faulty valves/gauges

The estimated small crude oil spill rate for the Alaska North Slope is 187 spills per billion barrels produced (Table G-7). The estimated mean number, size, and total volume of small crude spills for each of the alternatives are shown in Table G-8. For the small crude oil spill analysis, the estimated mean number of small spills is used as the assumed number of small spills.

Table G–8. Small crude oil spills estimated over the exploration, development, and production life of the National Petroleum Reserve-Alaska

Alternative	Resources (Bbbl)	Spill rate (spills/Bbbl)	Assumed spill size (bbl)	Estimated mean number of spills[1]	Estimated total spill volume (bbl)
A	0.723	187	3	135	405
B-1	0.505	187	3	94	282
B-2	0.549	187	3	103	309
C	0.707	187	3	132	396
D	0.761	187	3	142	426

bbl = barrels; Bbbl = billion barrels

1. The estimated mean number of small crude oil spills is estimated from the resource volume multiplied by the spill rate and is rounded to the nearest whole number.

G.1.2.2 Historical Small Refined Oil Spill Rates and Types of Spills on the North Slope

Typical refined products spilled on the Alaska North Slope are aviation fuel, diesel fuel, engine lube, fuel oil, gasoline, grease, hydraulic oil, transformer oil, and transmission oil. On the Alaska North Slope, diesel spills represent 52 percent of refined oil spills by frequency and 74 percent by volume. Engine lube oil spills are 11 percent by frequency and 5 percent by volume. Hydraulic oil spills are 32 percent by frequency and 13 percent by volume. Aviation fuel is 0.3 percent by frequency and 2 percent by volume. All other categories of refined spills are less than 1 percent by frequency and volume.

Small, refined oil spills occur in conjunction with oil exploration and production. From 1989 to 2009, the spill rate for small, refined oil spills was 540 spills per billion barrels produced (Table G-9). The estimated mean number, size, and total volume of small, refined spills for each of the alternatives are shown in Table G-10. For the small, refined oil spill analysis, the estimated mean number of small spills is used as the assumed number of small spills.

Table G–9. Small refined-oil spills: Estimated spill rates for the Alaska North Slope

Small refined-oil spills <500 barrels, 1989-2009	
Total Volume of Refined Spills	4, 226 barrels
Total Number of Spills	5,026 spills
Mean (Average) Spill Size	0.8
Median Spill Size	5 gallons
Production (Crude Oil)	9.4 billion barrels
Spill Rate	540 spills/billion barrels of crude oil produced

Note: Oil-spill databases are from the Alaska Department of Environmental Conservation, Anchorage, Juneau, and Fairbanks. Alaska North Slope production data are derived from the Trans-Alaska Pipeline System throughput data from Alyeska Pipeline.

Table G–10. Small refined oil spills less than 500 barrels estimated over the exploration, development, and production life of the National Petroleum Reserve-Alaska

Alternative	Resources (Bbbl)	Spill rate (Spills/Bbbl)	Assumed spill size (bbl)[1]	Estimated mean number of spills[2]	Estimated total spill volume (bbl)
A	0.723	540	0.8	390	312
B-1	0.505	540	0.8	273	218
B-2	0.549	540	0.8	296	237
C	0.707	540	0.8	382	306
D	0.761	540	0.8	411	329

bbl = barrels; Bbbl = billion barrels

1. The mean spill size for refined spills on the Alaska North Slope from 1989 through 2009; equivalent to 35 gallons.
2. The fractional estimated mean spill number and volume are rounded to the nearest whole number.

G.1.3 Very Large Oil Spill - Greater Than or Equal to 120,000 Barrels

Unexpected and accidental large spills are unlikely but could possibly result from NPR-A exploration or development operations involving facilities or pipelines. However, incidents with the greatest potential for severe consequences are losses of well control with uncontrolled releases of large volumes of oil, where primary and secondary barriers fail, the well does not bridge (bridging occurs when the wellbore collapses and seals the flow path), and the flow is of long duration (Holand 1997).

Very large spills happen very infrequently, and there are limited data for use in the BLM's statistical analysis and predictive efforts. In general, historical data show that loss of well control events resulting in oil spills are very infrequent and that those resulting in large accidental oil spills are even rarer events (Anderson and Labelle 2000; Anderson, Mayes, and LaBelle 2012; Bercha Group 2006, 2008; Izon et al. 2007). The Norwegian SINTEF Offshore Blowout Database, which tracks worldwide offshore oil and gas blowouts, where risk-comparable drilling operations are analyzed, supports the same conclusion (International Association of Oil & Gas Producers 2010). New Outer Continental Shelf drilling regulations and recent advances in containment technology may further reduce the frequency and size of oil spills from offshore operations. However, as the 2010 Deepwater Horizon event illustrated, there is a very small chance for very large spills to occur and result in unacceptable impacts, some of which have the potential to be catastrophic.

A fundamental challenge is to accurately describe this very small risk, especially since there have been relatively few large oil spills that can serve as benchmarks (Scarlett et al. 2011; USDOI, Bureau of Ocean Energy Management 2012; Section 4.2.2). Generally wells within NPR-A would be onshore or directionally drilled from shore to reach the nearshore waters or lagoons of NPR-A. Therefore, it was most relevant to consider historic onshore very large spills.

The frequency of a very large spill occurring is very low. Internationally, from 1965 through 2010, four onshore oil well control incidents, resulting in an oil spill of greater than or equal to 120,000 barrels, were identified from the peer reviewed and "gray" literature (Table G-11). The largest onshore blowout, called the Lakeview gusher, was estimated to be 9.4 million bbl, half of which was estimated to reach the environment or evaporate. The Lakeview gusher incident in 1910 in California is not considered in this analysis because drilling techniques have evolved substantially since it occurred.

There were roughly 1.066 trillion barrels of oil produced worldwide from 1965–2010 (British Petroleum 2011). The BLM uses worldwide production as an exposure variable because the number of exploration wells worldwide is not readily available. These data provide an approximate occurrence rate of about 1 very large oil spill from an onshore blowout worldwide for approximately every 270 billion barrels of oil produced worldwide. Using international data increases the size of the data set and is more likely to capture rare events. However, it assumes that non-U.S. events are relevant to U.S. events to the extent that technology, maintenance, operational standards, and other factors are equal; but this may not be the case.

Table G–11. Historical very large oil spills from onshore well control incidents 1910-2010

Name	Company	Spill source	Location	Oil	Begin	End	Duration	Billion barrels	Source
Lakeview Gusher	Lakeview Oil Company	Well	United States, Kern County, California	Crude	3/14 1910	9/ 1911	18 months	9,000,000	Anonymous, 2002
Well No. 5 Fergana Valley	Uzbekneft	Well	Uzbekistan, Fergana Valley, Mingulak oil field	Crude	3/2 1992		>4 weeks	2,095,238	OSIR, 1998, Fingas, 2000
Dubai		Dev. Well		Crude	1973			2,000,000	Gulf Canada Resources Inc, 1982
D-103	Occidental of Libya	Prod Well	Libya, near al Fuqaha	Crude	8/11 1980		5 months	1,000,000	Fingas, 2000
Ora B. Jones #3	Richey& Company In	Expl. Well	U.S. Ranger, Texas, Eastland Co.	Crude	11/6 1985	11/14 1985	8 days	326,000	Fingas, 2000, Quinal et al., 2005

Note: Cells with no data means the information is not readily available in the open literature.

Sources: Compiled from cited references

State of Alaska regulation 18 ACC 75.434 states that (1) the response planning standard for an exploration facility is 16,500 barrels (5,500 barrels of oil per day for 3 days), unless relevant well data, exploration data, and other supporting technical documentation provided to the department and to the Alaska Oil and Gas Conservation Commission demonstrates to the satisfaction of the department that a lower response planning standard volume is appropriate; and (2) an additional 5,500 barrels for each of 12 days beyond 72 hours, unless relevant well data, exploration data, and other supporting technical documentation provided to the department and to the Alaska Oil and Gas Conservation Commission demonstrates to the satisfaction of the department that a lower response planning standard volume is appropriate.

G.2 Oil Weathering and Spreading

Information about large crude oil spill weathering and the aerial extent of an oil spill in the National Petroleum Reserve-Alaska lagoon waters were estimated from the SINTEF oil weathering model and historical climatology information.

G.2.1 Modeling Simulations of Large Oil Weathering

To judge the effect of a large oil spill, the following volumes must be estimated:

- the amount of oil that evaporates;
- the amount of oil that naturally disperses; and
- the amount of oil that remains after a certain time period.

Alpine field crude oil was used as the analog of oil types in the planning area. Weathering estimates of Alpine field crude oil and Arctic diesel (over a 30-day period) were derived by the SINTEF Oil Weathering Model (OWM), Version 4.0 (Reed et al. 2004).

Individual weathering results for Alpine field crude oil spills from the SINTEF OWM model are shown in Table G-12 and Table G-13. The SINTEF OWM changes both oil properties (density, viscosity, pour point, flash point, and water content) and physical properties (spreading, evaporation, oil-in-water dispersion, and water uptake) of the oil. The OWM performs a 30-day time horizon on the model weathering calculations, but with a warning that the model is not verified against experimental field data for more than 4 to 5 days. The SINTEF OWM has been tested extensively with results from three full-scale field trials of experimental oil spills (Daling and Strom 1999). The SINTEF OWM does not incorporate the effects of: currents, beaching, containment, photo-oxidation, microbiological degradation, adsorption to particles or encapsulation by ice.

Table G–12. Fate and behavior of a hypothetical 5,100-barrel oil spill from lagoon pipelines[1]

Features	Summer spill[2]				Meltout spill[3]			
Time after spill in days	1	3	10	30	1	3	10	30
Oil remaining (percent)	65.8	55.3	36.3	13.0	68.8	61.3	48.6	56.3
Oil dispersed (percent)	4.8	11.3	26.8	47.5	0.2	0.6	1.4	3.4
Oil evaporated (percent)	29.4	33.4	36.9	39.5	28.5	32.5	36.7	40.3
Thickness (mm)	3.1	1.9	1.1	1.0	4.6	2.7	1.5	1.0
Discontinuous area (square miles)[4]	0.6	17.1	81.5	338.1	3.3	13.5	33.1	265.9
Estimated coastline oiled (mi)[5]	52				57			

1. Calculated with the SINTEF Oil Weathering Model Version 4.0 (Reed et al. 2004), assuming an Alpine field crude type.
2. Summer (July through September) and assumes: 12-knot wind speed, 33 degrees Fahrenheit, and 1.3-feet (0.4-meter) wave height.
3. Spill is assumed to occur in May into first-year ice, pools 0.8 inches (2 cm) thick on ice surface for 2 days at 32 degrees Fahrenheit before meltout into 50% ice cover, 11-knot wind speed, and 0.3 feet (0.1 meter) wave heights.
4. Calculated from Equation 6 of Table 2 in Ford (1985), and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Ice dispersion occurs for about 30 days before meltout.
5. Calculated from Equation 17 of Table 4 in Ford (1985), and is the result of stepwise multiple regression for length of historical coastline affected.

Table G–13. Fate and behavior of a hypothetical 900-barrel oil spill from a lagoon facility[1]

Features	Summer spill[2]				Meltout spill[3]			
Time after spill in days	1	3	10	30	1	3	10	30
Oil remaining (percent)	75.5	68.4	57.9	40	76.9	71.8	64	56.5
Oil dispersed (percent)	0.5	1.6	6.1	20	0.1	0.2	1	3.5
Oil evaporated (percent)	24	30	36	40	23	28	35	40
Thickness (mm)	4.1	2.5	1.5	1	6.1	3.9	1.9	1.2
Discontinuous area (square miles)[4]	0.6	4.3	21.1	86.8	1.2	5.6	26.7	112.2
Estimated coastline oiled (mi)[5]	13.6				13.0			

1. Calculated with the SINTEF Oil Weathering Model Version 4.0 (Reed et al. 2004), assuming an Alpine field crude type.
2. Summer (July through September) assumes: 12-knot wind speed, 33 degrees Fahrenheit, and 1.3-feet (0.4-meter) wave height.
3. Spill is assumed to occur in May into first-year ice, pools 0.8 inches (2 cm) thick on ice surface for 2 days at 32 degrees Fahrenheit before meltout into 50% ice cover, 11-knot wind speed, and 0.3 feet (0.1 meter) wave heights.
4. Calculated from Equation 6 of Table 2 in Ford (1985), and is the discontinuous area of a continuing spill or the area swept by an instantaneous spill of a given volume. Ice dispersion occurs for about 30 days before meltout.
5. Calculated from Equation 17 of Table 4 in Ford (1985), and is the result of stepwise multiple regression for length of historical coastline affected.

The spill sizes chosen for oil weathering were 5,100 and 900 bbl for the Alpine field-type crude oil spill. Two general scenarios were simulated—one in which oil spills into open water, and another in which oil freezes into the ice and melts into 50 percent ice cover. It was assumed that open water occurs July through September, and that a winter spill melts out in July. For open water, the weathering of the 5,100- and 900-bbl spills was modeled as instantaneous spills. For the meltout spill scenario, the entire spill volume was modeled as an instantaneous spill. Although different amounts of oil could melt out at different times, the BLM assumed a conservative approach; all oil was released at the same time. Results are reported for the end of 1, 3, 10, and 30 days. The assumed fate and behavior of Alpine field crude oil and diesel oil, information that was used in the analysis of the effects of oil on environmental and social resources, are summarized in Table G-12 and Table G-13.

G.2.2 Observations of Historic North Slope Oil Spill Patterns

The development scenarios for alternatives A, B-1, B-2, C, and D include an onshore pipeline. Of greatest concern would be the potential contamination of the Colville River, because a pipeline could cross or underlie the Colville River and some of its tributaries, and Teshekpuk Lake.

Most oil and gas industry spills on the Alaska North Slope are confined to gravel pads and roads, and fewer records show crude and refined oil spills contacting the tundra. The Alaska Department of Environmental Conservation spill database did not contain a field for spills specifically occurring on the tundra until 1995 (Behr-Andres et al. 2001, Conn et al. 2001). From July 1995 to March of 2001, 106 reports of crude and refined oil spills to tundra were reported (Conn et al. 2001). During that same time period approximately 1,270 reports of refined and crude oil spills were reported. Approximately 8.4 percent of the spills on the Alaska North Slope were to tundra during this time period. For purposes of this analysis, the BLM assumes 10 percent of the spills are to tundra and 90 percent are on roads and pads. Conn et al. (2001) further characterized the occurrence of tundra spills.

Winter occurs for 8 to 9 months of the year on the North Slope and their analysis indicated 82 percent of the spills occurred during snow cover, 18 percent occurred during summer months and most of the spills were to wet tundra.

Those spills reaching the surrounding environment generally remain restricted to a limited area of the tundra unless they reach a river, stream, or other water body. The Alaska Department of Environmental Conservation records of crude and refined oil spills are not accurate enough to provide statistical spill size areas. The following are comments based on information from the Alaska Department of Environmental Conservation database and Behr-Andres et al. (2001). Off-pad spills that occur in or reach the environment generally cover a small area (less than or equal to 500 square feet). Larger areas of contamination occur when wind blows a fine oil mist over a large area. The largest area ever covered was the result of a pipeline spill on December 30, 1993, at drill site 5, well 23, which misted a fine oil spray of 4 barrels over a tundra area of 100 to 145 acres (Mueller 1997). Crude oil from a failed flowline spilled onto a gravel pad, reserve pit, and impoundment. High winds resulted in the crude oil being misted over the snow-covered tundra in an area approximately 330 feet wide and 1,300 feet long (Behr-Andres et al. 2001). Of the off-pad spills that occur, many contact snow or ice, which is cleaned up before the oil reaches the tundra. Smaller spills are likely to be contained within the snow layer, depending on snow depth and density. Larger spills are more likely to reach the ground surface. The Alaska Department of Environmental Conservation database documents that a spill at Point McIntyre covered approximately 23 acres of snow-covered tundra with 142 barrels of crude oil. Because this area was snow covered, there was little impact to the surrounding environment. If this spill had occurred during the summer, the impacts would have been very different.

G.3 Natural Gas Releases

This analysis evaluates the potential for a large gas release during natural gas development and production, as well as the potential impacts of such releases on the environment. This analysis identifies three general types of potential releases: from loss of well control at production platforms, from ruptured or leaking pipelines, and from onshore facilities. The following subsections discuss possible ways in which natural gas may be released into the environment, assign frequencies to notable events, and present hypothetical release scenarios for further environmental resource-specific analysis.

G.3.1 Loss of Well Control - Gas

It is possible that a loss of well control during natural gas production could cause a release of natural gas into the environment. Loss of well control is estimated at 3.6 x 10-4 gas blowouts per exploration well and 7.0×10^{-4} blowouts per development well drilled by International Association of Oil & Gas Producers (2010). The production well control incident rate for production of both oil and gas is 5.7×10^{-5} blowouts per well year (International Association of Oil & Gas Producers 2010).

The well control incident rate during production is lower than either the exploration or development drilling phase. A comparison of offshore and onshore rates indicated that rates were within less than an order of magnitude, suggesting that operational well blowout rates are relatively constant from onshore to offshore environments and from primary production to enhanced recovery to gas storage.

During sales-gas production, it is estimated that one well control incident of a single well on the facility could occur, releasing 10 million cubic feet of natural gas for 1 day. This is based on the average well production for one day from one well and estimated rates of blowout duration for production wells.

G.3.2 Ruptured Pipeline

Although unlikely, there exists some potential for a gas pipeline to rupture. The estimated significant incident rate for generic DOT onshore gas transmission lines from 1990-2009 is 1.5×10^{-4} per pipeline mile-year. For a 300-mile onshore pipeline, over a 20-year production life, the estimated number of significant incidents using the Department of Transportation's estimated rate is 0.9 significant incidents over the life of the project. Under Department of Transportation regulation, significant incidents are incidents that involve property damage of more than $50,000, injury, death, release of gas, or that are otherwise considered significant by the operator. It should be noted that the major cause of Department of Transportation transmission and distribution pipeline accidents is damage by digging near existing pipelines. The lack of population and activity on the Alaska North Slope could likely reduce the historical frequency for this causal factor.

A major release of dry natural gas would cause a sudden decrease in gas pressure, which in turn would automatically initiate procedures to close the valves on both ends of the ruptured segment of pipeline. Closure of the valves would effectively isolate the rupture and limit the amount of natural gas released into the environment. Given the daily flow rate and the estimated total number of valves, it is estimated that approximately 20 million cubic feet could be released within one pipe section between two valves.

Onshore, from an elevated pipeline the gas would disperse into the atmosphere. Underground, from a buried pipeline release, the gas would bubble to the surface and continue into the atmosphere, where it would dissipate.

G.3.3 Onshore Facility

Although unlikely, due to the enclosed space, there exists some potential for a gas leak and explosion at the onshore facility. The greatest hazard as a result of a natural gas leak is a fire or explosion. Methane has an auto-ignition temperature of 1,000 degrees Fahrenheit and is flammable at concentrations between 5 to 15 percent in air. Unconfined mixtures of methane in air are not explosive. However, a flammable concentration within an enclosed space in the presence of an ignition source can result in a potential explosion hazard.

G.3.4 Natural Gas Release Fate

Natural gas is primarily made of up methane CH_4 and ethane C_2H_6 which make up 85-90 percent of the volume of the mixture. Propane, butane, and heavier hydrocarbons can be extracted from the gas system and liquefied for transportation and storage. These are commonly known as liquid petroleum gas. Pentane through decane are the intermediate-weight hydrocarbons and are volatile liquids at atmospheric temperature and pressure. The common names for these are pentanes-plus, condensate, natural gasoline, and natural gas liquids). Produced gas is expected to be dry gas (no water or condensates).

The primary component of natural gas is methane, a colorless, odorless, and tasteless gas. It is not toxic in the atmosphere, but is classified as a simple asphyxiate, possessing an inhalation hazard. As with all gases, if inhaled in high enough concentration, oxygen deficiency could occur and result in suffocation. The specific gravity of methane is 0.55 (Air = 1.0). Being lighter than ambient air, it has the tendency to rise and dissipate into the atmosphere.

G.4 Cumulative Analysis of Oil Spills

This section discusses how the large oil spills for Effects of the Cumulative Case (section 4.8.4 Cumulative Oil Spills in volume 3) were estimated.

G.4.1 Preparing the Cumulative Oil Spill Analysis

To estimate the assumed number of large oil spills for the analysis of cumulative effects, the BLM used a future production estimate and large spill occurrence rates. The production estimate includes past, present, and future production for the Alaska North Slope and Beaufort and Chukchi seas. For cumulative case analysis, estimates are made for past, present and future production for the Alaska North Slope and adjacent Outer Continental Shelf areas in the Beaufort and Chukchi seas (Table G-14). For purposes of analysis, the high end of the Outer Continental Shelf range was used for a total of 11.24 billion barrels. The estimates for past activities include remaining proven reserves in already developed fields. The estimates for present activities include proven and probable resources reported for discovered fields expected to be developed in the near future. The estimates for future activities are based on undiscovered resources that may become future commercial projects under favorable conditions. All of these scenarios are predicated on high oil/gas prices (above $60 and up to $160), stable tax policies, continued operation of key infrastructure (Trans-Alaska Pipeline System), and no regulatory impediments or legal delays. Estimates for future production are much more uncertain because the fields have not been discovered and the above economic factors cannot be guaranteed for decades into the future.

Table G–14. Future production of conventional oil used in the cumulative impact analysis, 2012-2100

Area	Oil (billion barrels)
NPR-A	0.76
Colville-Canning (includes State Beaufort Sea)	3.15
Chukchi Sea Outer Continental Shelf	1.5-6.23
Beaufort Sea Outer Continental Shelf	0.5-1.10
Total	5.91-11.24

Sources: Thomas et al. 2009, USDOI Bureau of Ocean Energy Management 2012.

Note: The estimates of economically recoverable oil for NPR-A is that estimated in this plan for Alternative D. For the other alternatives, corresponding oil estimates would be: Alternative A—0.723 billion barrels; Alternative B-1—.0.505 billion barrels; Alternative B-2—0.549 billion barrels; Alternative C—.0.707 billion barrels.

The Trans-Alaska Pipeline System pipeline, onshore Alaska North Slope, and the Outer Continental Shelf have varying large spill rates and spill-size categories. For a summary of the spill rates and spill size categories that were assumed for analysis of oil spills in the cumulative case, see Table G-15. One noteworthy fact is that most oil originating from either onshore or offshore on the North Slope of Alaska flows through the Trans-Alaska Pipeline System pipeline and into Trans-Alaska Pipeline System tankers.

Table G–15. Oil spill rates and spill-size categories used to estimate large crude oil spills for the cumulative analysis

Location	Arctic Outer Continental Shelf		Alaska North Slope 1985-2010		Trans-Alaska Pipeline System Pipeline 1977-2010	
	Spill rate (spills/Bbbl)	Size category (bbl)	Spill rate (Spills/Bbbl)	Size category (bbl)	Spill rate (Spills/Bbbl)	Size category (bbl)
Offshore	1.13	≥1,000	-	-		
Onshore	-	-	0.65	≥500	0.55	≥500

Bbbl = billion barrels; bbl = barrels

G.4.2 Estimating Possible Future Large Spills from All Sources

The estimated mean number and volume of large spills for the cumulative case are shown in Table G-16 (next page). The cumulative case estimates for oil spill analysis are discussed in section 4.8.4, Volume 4. The Bureau of Ocean Energy Management (2012; Table 4.6.1-4) estimated 2-8 Outer Continental Shelf large spills could occur in offshore Outer Continental Shelf water depending upon a price assumptions ranging from $60 to of $160 per barrel. For purposes of analysis BLM used the higher end of the estimated resource range at $160 and the associated higher number of estimated spills for purposes of analysis.

Table G–16. Cumulative oil-spill-occurrence estimates greater than or equal to 500 barrels and greater than or equal to 1,000 barrels out to 2100 of the National Petroleum Reserve-Alaska

Category	Large crude oil spills				
	Reserves and resources (Bbbl)	**Spill rate [1.] (spills/Bbbl)**	**Size category (bbl)**	**Assumed size (bbl) pipeline/facility [2]**	**Number of large spills**
NPR-A					
Alternative A	0.723	0.65	≥500	5,100/900	1
Alternative B-1	0.505	0.65	≥500	5,100/900	1
Alternative B-2	0.549	0.65	≥500	5,100/900	1
Alternative C	0.707	0.65	≥500	5,100/900	1
Alternative D [3]	0.761	0.65	≥500	5,100/900	1
Colville Canning/State Beaufort Sea					
	3.15	0.65	≥500	700/700	2
Arctic Outer Continental Shelf (Beaufort and Chukchi Sea)					
Total	2.00-7.325 [a]	1.13 [b]	≥1,000	1,700/5,100	2-8 [c]
Trans-Alaska Pipeline System					
	5.91 - 11.24 [a]	0.55	≥500	4,000/na	3-6 [d]
Total [1]					
	5.91 - 11.24 [a]	-	-	-	8-17

Bbbl = billion barrels; bbl = barrels

1. Large spill occurrence rates for Alaska North Slope, OCS and TAPS Pipeline are discussed in this Appendix.

2.The first number is the assumed pipeline size and the second number is the assumed facility size. The highest pipeline or facility spill size in the Alaska North Slope spill record is used for the NPR-A assumed large spill size. All other assumed large spill sizes are median spill sizes.

3. For purposes of analysis BLM uses Alternative D for the summation of the total estimated production.

a. The reserves, resources and large spill numbers in section 4.7.4 in Volume 3 assume an oil price of $160.00/barrel. In this table the reserves, resources and large spill numbers reflect a range of $60.00 to $160.00/barrel.

b. The assumed number of large spills is from USDOI Bureau of Ocean Energy Management (2012). It is estimated using the 1996-2010 spill rates in USDOI, Bureau of Ocean Energy Management (2012). For the Arctic Outer Continental Shelf, the 1996-2010 spill rates were compared to fault-tree rates in Bercha Group Inc. (2008 a, b, 2006). The greater number of estimated spills is represented in Table 4.6.1-4 of USDOI Bureau of Ocean Energy Management (2012). The USDOI Bureau of Ocean Energy Management (2012) large Outer Continental Shelf spill rate is about twice the spill rate as Bercha Group Inc (2008 a, b, 2006).

c. The values provided for the Arctic Outer Continental Shelf are the combined totals for the Beaufort and Chukchi Seas. For purposes of analysis half (1-3) of the estimated Outer Continental Shelf large pipeline spills (1-6) are assumed to occur onshore. Of those, 1-2 spills could occur from a large diameter common carrier pipeline across the NPR-A/Alaska North Slope and up to 1 onshore spill between the Colville and Canning Rivers from Outer Continental Shelf production in the Beaufort Sea.

d. The estimated large Trans-Alaska Pipeline System pipeline spills include the pipeline, pump stations, and associated tank farms and could occur along the entire length. Of those, 1-2 could occur on the North Slope and 2-4 along the rest of the pipeline length.

Appendix H: Air Quality Related Values and Dispersion Modeling Results

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H.1 Introduction

The Bureau of Land Management (BLM) is undertaking the National Petroleum Reserve-Alaska (NPR-A) Integrated Activity Plan/Environmental Impact Statement (IAP/EIS) to determine the appropriate management of all BLM-managed lands in the NPR-A in light of new information about surface and subsurface resources and in a manner consistent with existing statutory direction.

The planning area includes all lands and only such lands as are managed by the BLM within the NPR-A. BLM-managed lands total approximately 22.5 million acres of surface and subsurface estate, approximately 429,000 of which are in bays, inlets, and lagoons. Nearly 250,000 additional acres of BLM-managed subsurface estate are under the Alaska Native Claims Settlement Act village corporation surface estate. (See Table 1-1 in Volume 1 and Map 1-1 in Volume 7; for a more detailed description of land status, see section 3.4.1. in Volume 1).

Modeling for the NPR-A project was originally conceived as a near-field/AERMOD effort only due to budget constraints (one-time end of year [FY'11] funds), lack of any Federal Class I areas in the vicinity of the project, and the large distance to any "sensitive" Class II areas (over 100 miles, which is well beyond the limitations of AERMOD).

The analysis protocol for the AERMOD modeling was under development when BLM was contacted by the U.S. Fish and Wildlife Service (FWS) to discuss possible long range transport modeling for potential impacts at the Arctic National Wildlife Refuge, managed by the FWS. After discussions with FWS, BLM agreed to perform this modeling for air quality related values (AQRV [visibility and atmospheric deposition]) impacts.

The AQRV modeling was done in collaboration with not only the FWS, but also with the National Parks Service (NPS), the USDA Forest Service (FS), and the Environmental Protection Agency (EPA) Region 10. Each agency contributed to the collaborative AQRV modeling effort as follows:

- BLM – Lead Agency – Project oversight and review, final CalPuff model runs, distribution of results and report preparation
- FWS – Preparation of AERMOD emissions for use in CalPuff, preparation of meteorological files, model code changes to allow use of polar stereographic coordinates and initial CalPuff runs
- EPA Regional 10 – Weather Research and Forecast (WRF) model output for use in CalPuff
- FS – Quality assurance (QA) of model code changes and model input files

The EPA-recommended CalPuff long-range transport model was used to estimate potential future AQRV impacts at the nearest “sensitive” Class II areas:

- Arctic National Wildlife Refuge (ANWR)
- Gates of the Arctic National Park and Preserve (Gates)

Highlights of the modeling methodologies are presented below, followed by the results of the AERMOD and CalPuff modeling.

H.2 Part I – AERMOD (Near-field)/NAAQS Results

The AERMOD modeling was performed by Golder Associates, Inc., under contract to the BLM Alaska State Office. The following information was extracted from their draft report to BLM, “Dispersion Modeling Assessment of Potential Future Development in the NPR-A - Air Quality Impact Assessments in Support of the Bureau of Land Management Integrated Activity Plan/Environmental Impact Statement Update.”

Methodology

Assessment Areas

The two general assessment areas, chosen after discussion with the BLM, were:

- Near Nuiqsut, Alaska
- Near Atqasuk, Alaska

Nuiqsut was chosen because:

- It represents a relatively large village for the Alaskan arctic coastal plain;
- It is nearest to significant existing areas developed by the oil and gas industry (e.g., Alpine Development, Kuparuk River Unit, Prudhoe Bay Unit, and Duck Island Unit);
- It has a full complement of ambient monitoring data expected to capture impacts from both the village and the oil and gas developments, and,
- It is regionally representative of areas near the land/sea interface.

Atqasuk was chosen because it represents one of the few villages well inland within the NPR-A and is closer to some of the wilderness areas near the southern edge of the NPR-A such as the Noatak National Preserve, Kobuk Valley National Park, and Gates of the Arctic National Park and Preserve.

Emissions

Sources that were explicitly included in the AERMOD modeling are those sources associated with a hypothetical joint oil development complex for both the construction and operation phases. In particular, the following source category emissions were considered.

Exploration

- Ice road construction
- Ice pad construction
- On-road transport for personnel and supplies

Drill Rig Operation

- Construction (Central Processing Facility (CPF) and Satellites)
- Gravel borrow pit operations at CPF
- Gravel pad construction (CPF and satellites)
- Gravel road construction
- Pipeline construction
- Gravel airstrip construction (at the CPF)
- Air and ground transport for personnel and supplies

Operation (CPF and Satellite)

- Drill rig operation
- Support equipment operation (turbines/generators, heaters, incinerators, flares, etc.)
- Air and ground transport for personnel and supplies

Because the BLM has not received any actual development proposals to date, a hypothetical development scenario, based on actual existing development facilities was assumed. A number of historic EIS and permit applications were reviewed. In addition, staff members with the BLM Alaska State Office were consulted to refine these data and fill in data gaps.

Although there are likely to be some differences between the assumed emission sources considered in this assessment and the actual emissions that would occur in the future from such activities, it is believed that the source activity levels discussed in this section, and the associated estimated air pollutant emissions, will provide a conservative estimate of actual future emissions. One reason that these emission are likely to be conservative is that many of the projected activities will occur well in the future (in some cases ten or more years out), when regulatory requirements, new source performance standards, and new technologies are likely to lead to lower emissions than those based on current regulations and technologies as assumed in this assessment.

Meteorological Data

Available representative surface meteorological data from the National Climatic Data Center for Nuiqsut and Atqasuk were reviewed. Five years of data were obtained at each site spanning 2007 through 2011. After reviewing the data, some years of data were removed from further use due to inadequate data capture. The following years were used in the AERMOD analyses:

- Nuiqsut, Alaska – 2007, 2009-2011
- Atqasuk, Alaska – 2007, 2008, 2011

All surface meteorological data sets were processed with Barrow, Alaska upper air data to produce model-ready meteorological data.

Model Receptors

Outside of the 500 meter exclusion zone, an area around each development sites with signage and security to prevent the public from entering, model receptors were placed in a rectilinear grid as follows:

- At 100 meter spacing to a distance of 2,000 meters from the centroid of the emission sources.
- At 250 meter spacing to a distance of 4,000 meters from the centroid of the emission sources.
- At 1,000 meter spacing to a distance of 10,000 meters from the centroid of the emission sources.
- At 2,500 meter spacing to a distance of 50,000 meters from the centroid of the emission sources.

In addition, receptors were placed every 50 meters around the ambient air boundary surrounding each activity location (e.g. drilling pad, construction site, etc.). Flat terrain was assumed for all modeling.

The exception to this approach was along roadways, which due to limited control of the off-source areas and the relative consistency of their source-receptor geometry, have a smaller exclusion zone (100 meters) and no specific boundary line of receptors (e.g., impacts will be picked up within the regular grid of receptors). This was necessary to keep the total number of receptors in the modeling analysis to a reasonable value for computational purposes.

Background Air Quality Data

The Alaska Department of Environmental Conservation (ADEC) does not operate ambient air quality monitoring sites in the North Slope. The available ambient pollutant monitoring data have been collected by energy development companies and researchers. This data is shown in Table H-1 below along with the National Ambient Air Quality Standards (NAAQS).

Monitoring data for Hazardous Air Pollutants (HAPs) are not available in the study area. Background concentrations were added to modeled concentrations for comparison to the NAAQS.

Table H–1. Background concentrations and NAAQS

Pollutant	Averaging Time	Years Used	Calculated Background Conc. ($\mu g/m^3$)	NAAQS($\mu g/m^3$)
NO_2	1-hr	2009-2011	39.5	188
	Annual	2009-2011	2.8	100
PM_{10}	24-hr	2009-2011	117	150
$PM_{2.5}$	24-hr	2009-2011	10	35
	Annual	2009-2011	1.13	15
CO	1-hr	2009-2011	1,947	40,000
	8-hr	2009-2011	1,231	10,000
SO_2	1-hr	2009-2011	44.5	196
	3-hr	2009-2011	19.8	1,300

$\mu g/m^3$ = micrograms per cubic meter (1 microgram equals 1x10-6 gram)

The AERMOD model has the ability to utilize measured hourly ambient ozone concentration data to estimate the conversion rate of nitrogen monoxide (NO) to nitrogen dioxide (NO_2) between the point of emission and the ambient receptor. Although there are several ways that this can be accomplished in AERMOD, the Ozone Limiting Method (OLM) was utilized for this study. The OLM method requires that in-stack NO:NO_x ratios be provided for each source. This method also requires hourly background ozone data. An ambient equilibrium NO_2:NO_x ratio of 0.9 was also used. Hourly ozone data collected at the Nuiqsut monitoring site were paired with the hourly meteorological data used for the modeling for the same date and hour.

This Tier 3 analysis is consistent with the U.S. EPA guidance documents (USEPA 2010b, 2011a) on modeling analyses for the 1-hour NO_2 standard.

Air Modeling Results

Table H–2. AERMOD modeling results – Nuiqsut meteorological data; all scenarios

		Total Concentrations(µg/m³)			
Pollutant	**Averaging Time**	**Max – All Sources[a] with/without background**	**Max – Hypothetical Village[a] with/without background**	**NAAQS (µg/m³)**	**PSD Class II Increment[b]**
NO_2	1-hr	459/419	126.5/87.0	188	---
	Annual	10.89/8.07	3.79/0.97	100	25
PM_{10}	24-hr	221/103.7	128/11.4	150	30
$PM_{2.5}$	24-hr	20/10	11.0/1.03	35	---
	Annual	2.63/1.50	1.29/0.16	15	4
CO	1-hr	2,754/808	2,089/142	40,000	---
	8-hr	1,622/391	1,266/35.5	10,000	---
SO_2	1-hr	59.1/14.6	47.7/3.15	196	---
	3-hr	33.6/13.8	23.4/3.55	1,300	512

a. Includes background concentrations

b. Background concentrations not included when comparing to Prevention of Significant Deterioration (PSD) Increments

Table H–3. AERMOD modeling results – Atqasuk meteorological data; all scenarios

		Total Concentrations(µg/m³)			
Pollutant	**Averaging Time**	**Max – All Sources[a] with/without background**	**Max – Hypothetical Village[a] with/without background**	**NAAQS (µg/m³)**	**PSD Class II Increment[b]**
NO_2	1-hr	420/380	100/60.6	188	---
	Annual	11.2/8.35	3.80/0.98	100	25
PM_{10}	24-hr	307/190	134/17.1	150	30
$PM_{2.5}$	24-hr	20.2/10.2	11.1/1.10	35	---
	Annual	2.40/1.27	1.24/0.11	15	4
CO	1-hr	2,744/797.9	2,071/124	40,000	---
	8-hr	1,746/514.9	1,273/42.7	10,000	---
SO_2	1-hr	57.0/12.5	47.5/2.95/	196	---
	3-hr	34.7/14.9	23.8/4.02	1,300	512

a. Includes background concentrations

b. Background concentrations not included when comparing to Prevention of Significant Deterioration (PSD) Increments

Numerous HAPs were also included in the modeling for the three scenarios for three averaging times depending on the pathway for health effects. The thresholds for each averaging period are:

Non-cancer Health Effects

- 1-hour average (acute) – Acute Exposure Guideline Levels (AEGL; acute exposure levels for 1-hour mild effects [AEGL-1])
- 24-hour (sub-chronic) – (Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Level (MRL; for no adverse effects for 1 – 14 day exposures
- Annual (chronic) – Prioritized chronic dose-response values for screening risk assessments

Incremental Cancer Risk

Prioritized chronic dose-response values for screening risk assessments; a unit risk is an upper-bound excess lifetime cancer risk estimated to result from continuous exposure for a lifetime to an agent at a concentration of 1 $\mu g/m^3$ in air.

The modeling results show that non-cancer health effects thresholds were not exceeded for either the maximum overall impact or village impacts. None of the village impacts exceeded the cancer effects threshold.

The screening thresholds for Arsenic (Atqasuk) and Arsenic and Cadmium (Nuiqsut) for cancer effects were slightly exceeded and only at locations where members of the public would not be present for extended periods of time.

For the cumulative assessment, the ADEC identified 38 major stationary sources in the North Slope and 37 minor stationary sources requiring air quality permits. Major sources accounted for 96 percent of the total potential emissions from these sources. By far the majority of the permitted stationary emission sources on the North Slope are associated with the oil and gas industry, followed by electric power generation.

The cumulative model results showed no exceedance of any NAAQS.

H.3 Part II – CalPuff/AQRV Results

As mentioned in the introduction, CalPuff long range transport modeling was included after project initiation in response to a request from FWS and the National Park Service (NPS). The FWS suggested that modeling for AQRVs (visibility impairment and atmospheric deposition) be conducted to estimate potential future impacts at the Arctic National Wildlife Refuge (ANWR). The NPS park (Gates of the Arctic) was also added due to its proximity to the NPR-A.

The EPA-recommended long range transport model CalPuff was used for this assessment. A few highlights of the modeling methodology are presented below.

Methodology

The types and number of sources used in the CalPuff analysis are essentially the same as those from the AERMOD modeling. Minor changes were needed to translate the emissions into a CalPuff-ready format. Locations of the sources were also different given the different models' configuration and operation as well as the type of results required. The HAPs and other emissions that do not contribute to atmospheric deposition and visibility impacts were not included.

Because of the high arctic location of this analysis, it was necessary to use a polar stereographic map projection rather than the typical Lambert Conformal projection. The CalPuff model code had to be changed (added to) to accommodate the polar coordinate system. The code changes were written by the FWS and reviewed by the FS, along with graphics and animations of the model behavior. All indications were that the model was functioning appropriately.

The meteorological data for this analysis was provided by EPA Region 10. Weather Research and Forecast (WRF) model output was provided for the years 2007 – 2009 to BLM and the FWS. When FWS began reviewing the data, it was discovered that, for each year of data, only approximately 5.5 months (mid-June to end of November) of data for each year were present. This data was originally produced for modeling emissions for drilling platforms in the Beaufort and Chukchi seas, and reflects the period of operation of those sources.

Model receptors for the ANWR and Gates Class II areas were developed by the FWS and NPS, in concert with their respective Geographic Information Systems (GIS) staffs. Receptors were placed along the border of the park closest to the NPR-A and then spaced approximately 5 kilometers (km) in for a total of 4 rows of receptors covering about 20 km from the leading edge of the park.

Background AQRV data were not available for either of the Class II areas included in the analysis. Therefore, background data was taken from the nearest Class I area, Denali National Park (located about 325 km from the closest boundary of the NPR-A).

When the modeling utilizing the 2007-2009 meteorological data was nearly complete, one full year of WRF meteorological data was made available by the Bureau of Ocean Energy Management (BOEM) through their contract with the University of Alaska – Fairbanks for 2009. Although the partial-year 2009 data was already in use, a separate modeling run was performed with the BOEM data. This full year of WRF model data was processed differently (model options, switches, etc.) and on a different grid resolution (10 km for the BOEM data vs. 12 km for the partial year data). Because of these differences, it was decided that a separate model run was warranted.

The modeling domain was approximately 912 km by 660 km covering the project and receptor areas and beyond to allow proper model operation.

Results

The results of the CalPuff AQRV modeling are presented below. All results are for hypothetical project sources only.

Table H–4. Final visibility results for 3 years of partial meteorological data

Year	Max delta DV anywhere in domain	Number of Days >0.5 delta DV	Number of Days >1.0 delta DV
Alaska National Wildlife Refuge (ANWR)			
2007	0.51	1	0
2008	2.16	8	5
2009	2.85	24	13
Gates of the Arctic National Park and Preserve			
2007	1.71	4	2
2008	1.5	5	2
2009	5.53	41	20

DV = Deciview (the DV scale is linear to humanly-perceived changes in visual air quality and is analogous to the Decibel scale). Delta = Change

Table H–5. Final visibility results for 1 full year of meteorological data

Year	Max delta DV anywhere in domain	Number of Days >0.5 delta DV	Number of Days >1.0 delta DV
Alaska National Wildlife Refuge (ANWR)			
2009	2.18	33	8
Gates of the Arctic National Park and Preserve			
2009	2.65	51	19

DV = Deciview (the DV scale is linear to humanly-perceived changes in visual air quality and is analogous to the Decibel scale). Delta = Change

Table H–6. Final deposition* results for 3 years of partial meteorological data

Year	Total Nitrogen Deposition (kg/ha/yr)	Total Sulfur Deposition (kg/ha/yr)	Deposition Analysis Thresholds (kg/ha/yr)
Alaska National Wildlife Refuge			
2007	0.001	0.0002	0.005
2008	0.0084	0.0007	0.005
2009	0.002	0.0003	0.005
Gates of the Arctic National Park and Reserve			
2007	0.0071	0.001	0.005
2008	0.0095	0.0008	0.005
2009	0.0052	0.0006	0.005

* Deposition modeling was not done for full year of 2009 meteorological data

kg/ha/yr = kilograms per hectare per year (a hectare is a metric unit equal to 2.47 acres)

Glossary

A

Acidophilus: Acid-loving (as in bacteria or plants); growing well in an acid medium.

Active floodplain: The flat area along a waterbody where sediments are deposited by seasonal or annual flooding; generally demarcated by a visible high water mark.

Aerial: Consisting of, moving through, found in, or suspended in the air.

Alluvial: Sedimentary material consisting mainly of coarse sand and gravel.

Alternatives: The different means by which objectives or goals can be attained. One of several policies, plans, or projects proposed for decision making.

Ambient: A term used to describe the environment as it exists at the point of measurement and against which changes (impacts) are measured.

Ambient air quality standard: Air pollutant concentrations of the surrounding outside environment that cannot legally be exceeded during fixed time intervals within a specific geographic area.

Amphidromous: A term used to describe fish that spawn and overwinter in rivers and streams, but migrate during the ice-free summer from these freshwater environments into coastal waters for months to feed.

Anadromous: A term used to describe fish that mature in the sea and swim up freshwater rivers and streams to spawn. Salmon, steelhead, and sea-run cutthroat trout are examples.

Anticline: An inverted bowl-shaped structure formed when sedimentary rock layers are folded to produce an arch or elongated dome.

Anoxic: The condition of an environment in which free oxygen is lacking or absent.

Anthropogenic: Of, relating to, or resulting from the influence of human beings on nature.

Aquatic: Growing, living in, frequenting, or taking place in water; in this IAP/EIS, used to indicate habitat, vegetation, and wildlife in freshwater.

Aromatic hydrocarbon: A hydrocarbon with a molecular structure involving one or more benzene unsaturated resonant rings of six carbon atoms, and having properties similar to benzene, which is the simplest of the aromatic hydrocarbons.

Archaeological resource: Place(s) where the remnants (e.g., artifacts) of a past culture survive in a physical context that allows for the interpretation of these remains. Archaeological resources can be districts, sites, buildings, structures, or objects and can be prehistoric or historic in nature.

Aufeis: Thick ice that builds up as a result of repeated overflow.

Authorized Officer (AO): Designated agency personnel responsible for a certain area of a project; for the National Petroleum Reserve-Alaska, generally the BLM State Director.

Available: When referring to oil and gas leasing, available lands could be offered for oil and gas leasing. Lands that are already leased could be offered for leasing if the existing lease ceases to exist.

B

Barrel: Unit of measurement consisting of 42 gallons of oil or other fluid.

Baseline data: Data gathered prior to the proposed action to characterize pre-development site conditions.

Biodegradable: Capable of being broken down by the action of living organisms such as microorganisms.

Biological Assessment (BA): A document prepared by or under the direction of a federal agency; addresses listed and proposed species and designated and proposed critical habitat that may be present in the action area, and evaluates the potential effects of the action on such species and habitat.

Black water: Discharge that includes wastewater from any or all of the following: toilets, urinals, sewage treatment systems.

Bonding capacity: An amount, determined by market analysts, based on a government entity's prior bonding experience, actual repayment performance, and its ability to service future, periodic debt. It affects the ability of municipalities to issue and sell bonds to generate funds for capital improvements.

Bore-hole: The opening in the ground that is created when drilling a well; may refer to the inside diameter of the bore-hole wall, the rock face that bounds the drilled hole.

Bottomfast ice: Ice that is firmly attached or grounded to the bottom of a waterbody, which is often frozen from top to bottom.

Brackish: Water that is intermediate between salt and fresh water; often occurs at the mouths of rivers, where fresh water mixes with salt water.

Brine: General description of water that is produced with oil. The water is associated with the oil-producing formation and can have varying amounts of dissolved salts.

Brood: A group of young birds being cared for by an adult bird; generally the surviving hatchlings from one or more clutches of eggs.

Bureau of Land Management (BLM): An agency of the United States government, under the U.S. Department of the Interior, responsible for administering certain public lands of the United States.

Burin: A tool flaked into a chisel point for inscribing or grooving bone, wood, leather, stone, or antler.

C

Calving area: A large area where large mammals, particularly ungulates such as caribou, congregate to give birth to their young.

Capital expenses: The money spent to purchase or upgrade physical assets, such as buildings or machinery.

Carrion: Dead or dying flesh of animals.

Class I air quality area: One of 156 protected areas such as national parks (over 6,000 acres), wilderness areas (over 5,000 acres), national memorial parks (over 5,000 acres), and international parks that were in existence as of August 1977, where air quality should be given special protection. Federal Class I areas are subject to maximum limits on air quality degradation called air quality increments (often referred to as Prevention of Significant Deterioration [PSD] increments). All areas of the United States not designated as Class I are **Class II** areas. The air quality standards in Class I areas are more stringent than national ambient air quality standards.

Council on Environmental Quality (CEQ): An advisory council to the President of the United States; established by the National Environmental Policy Act of 1969. It reviews federal programs for their effect on the environment, conducts environmental studies, and advises the President on environmental matters.

Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA): An act that provided the authority for money administered by the Environmental Protection Agency to identify and clean up hazardous waste sites; also known as Superfund.

Code of Federal Regulations (CFR): A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.

cfs: Cubic feet per second; 1 cfs equals 448.33 gallons per minute.

Commercial field: Oil or natural gas fields that can be produced such that they provide a suitable return on investment.

Commercial oil (or natural gas) reserves: Oil or natural gas reserves that can be produced such that they provide a suitable return on investment.

Commercially recoverable: See commercial oil (or natural gas) reserves.

Concern: A point, matter, or question raised by management or the public that must be addressed in the planning process.

Conglomerate: Sedimentary rock consisting of gravel and small boulders.

Consistency determination: A finding by a state or federal agency that a project or agency action is consistent with a required agency program, guideline, or regulation, such as the Alaska Coastal Zone Management Program.

Consultation: Exchange of information and interactive discussion; when the "C" in consultation is capitalized it refers to consultation mandated by statute or regulation that has prescribed parties, procedures, and timelines (e.g., Consultation under NEPA or section 7 of the Endangered Species Act).

Criteria: Data and information that are used to examine or establish the relative degrees of desirability of alternatives or the degree to which a course of action meets an intended objective.

Criteria air pollutants: The six most common air pollutants in the U.S.: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (both PM_{10} and $PM_{2.5}$ – inhalable and respirable particulates), and sulfur dioxide (SO_2). Congress has focused regulatory attention on these six pollutants because they endanger public health and the environment, are widespread throughout the U.S., and come from a variety of sources. Criteria air pollutants are typically emitted from many sources in industry, mining, transportation, electricity generation, energy production and agriculture.

Cultural resources: The remains of sites, structures, or objects used by humans in the past, historic or prehistoric. More recently referred to as heritage resources.

Cumulative effects or impacts: The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions, taken place over a period of time.

D

Deferred: When referring to oil and gas leasing, deferred indicates that lands would not be offered for lease until a specified period has expired. For example, a ten-year deferral would mean that the deferred lands would not be offered for leasing until the expiration of ten years from the Record of Decision establishing the ten-year deferral.

Demersal: Living near, deposited on, or sinking to the seabed.

Density: The number of individuals per a given unit area.

Deposit: A natural accumulation, as of precious metals, minerals, coal, gas, and oil that may be pursued for its intrinsic value; gold deposit.

Development: The phase of petroleum operations that occurs after exploration has proven successful, and before full-scale production. The newly discovered oil or gas field is assessed during an appraisal phase, a plan to fully and efficiently exploit it is created, and additional wells are usually drilled.

DEW-Line: Distant Early Warning-Line. A site designed and built during the Cold War as the primary line of air defense warning of "Over the Pole" invasion of the North American Continent.

Dilution: The act of mixing or thinning, and therefore, decreasing a certain strength or concentration.

Dispersion: The act of distributing or separating into lower concentrations or less dense units.

Dissociable: Able to break up into simpler chemical constituents.

Diversity: An expression of community structure; high if there are many equally abundant species; low if there are only a few equally abundant species. The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

Draft Environmental Impact Statement (DEIS): The draft statement of the environmental effects of a major federal action, which is required under section 102 of the National Environmental Policy Act, and released to the public and other agencies for comment and review.

Drilling fluid (mud): A preparation of water, clay, and chemicals circulated in a well during drilling to lubricate and cool the drill bit, flush rock cuttings to the surface, prevent sloughing of the sides of the hole, and prevent the flow of formation fluids into the bore-hole or to the surface.

Drilling pad: A temporary drilling site, usually constructed of local materials such as gravel.

Duck pond: A small, flat-bottomed plastic receptacle placed under a vehicle to catch and contain any contaminated fluids that may melt or drip from the underside of the vehicle.

E

Economically recoverable: See commercially recoverable.

Effect: Environmental change resulting from a proposed action. Direct effects are caused by the action and occur at the same time and place, while indirect effects are caused by the action, but are later in time or further removed in distance, although still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems. Effect and impact are synonymous as used in this document.

Employment: Labor input into a production process, measured in the number of person-years or jobs; the number of jobs required to produce the output of each sector. A person-year is approximately 2,000 working hours by one person working the whole year or by several persons working seasonally. A job may be 1 week, 1 month, or 1 year.

Endangered species: Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range; plant or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.

Energy budget: The flow of energy through an organism or ecosystem. For an organism, it is the amount of energy being absorbed (e.g., food) in relation to the amount of energy expended and lost as heat.

Environment: The physical conditions that exist within an area (e.g., the area that will be affected by a proposed project), including land, air, water, minerals, flora, fauna, ambient noise, and objects of historical or aesthetic significance. The sum of all external conditions that affect an organism or community to influence its development or existence.

Environmental Assessment (EA): A concise public document, for which a federal agency is responsible, that serves to: (1) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; (2) aid an agency's compliance with the National Environmental Policy Act when no environmental impact statement is necessary; and, (3) facilitate preparation of an environmental impact statement when one is necessary.

Environmental Justice: The fair treatment and meaningful involvement of all people, regardless of natural origin or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socio-economic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898 directs federal agencies to achieve environmental justice as part of their missions by identifying and addressing disproportionately high adverse effects of agency programs, policies, and activities, on minority and low-income populations.

Environmental Impact Statement (EIS): An analytical document prepared under the National Environmental Policy Act (NEPA) that portrays the potential impacts to the environment of a Preferred Action and its possible alternatives. An ElS is developed for use by decision-makers to weigh the environmental consequences of a potential decision.

Erosion: The wearing away of the land surface by running water, wind, ice, or other geologic agents, including gravitation creep.

Eskimo: An ethnonym (name given to a group by another group) referring to speakers of the Inuit language family who live in the Arctic and Subarctic regions of North America (e.g., Canada, Greenland, and Alaska) and eastern Siberia.

Essential Fish Habitat (EFH): As defined by Congress in the interim final rule (62 FR 66551): "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." For the purpose of interpreting the definition of EFH habitat, "waters" include aquatic areas and their associated physical, chemical, and biological properties; "substrate" includes sediment underlying the waters; "necessary" refers to the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types utilized by a species throughout its life cycle.

Estuary: An estuary is a partially enclosed body of water formed where freshwater from rivers and streams flows into the ocean, mixing with the salty seawater. Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water.

Ethnographic: Of or pertaining to the descriptive and analytical study of the culture of particular self-defined groups or communities.

Exploration: The search for economic deposits of minerals, gas, oil or coal through the practices of geology, geochemistry, geophysics, drilling, shaft sinking, and/or mapping.

Exploratory unit: Exploratory units normally embrace a prospective area delineated on the basis of geological and/or geophysical inference and permit the most efficient and cost-effective means of developing underlying oil and gas resources.

F

°F: Degrees Fahrenheit.

Fast-ice zone: Area along the coast covered by sea ice that is continuous with and attached to the shoreline.

Feasible: Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors.

Final Environmental Impact Statement (Final EIS): A revision of the Draft Environmental Impact Statement that includes public and agency comments on the draft.

Fisheries habitat: Streams, lakes, and reservoirs that support fish populations.

Fishery: The act, process, occupation, or season of taking an aquatic species.

Floodplain: The lowland and relatively flat area adjoining inland waters, including, at a minimum, that area subject to a 1 percent or greater chance of flooding in any given year.

Fluvial: Of or relating to a stream or river.

Fossil: Evidence or remnant of a plant or animal preserved in the earth’s crust (e.g., skeleton, footprint, or leaf print).

Fossil fuel: Petroleum, natural gas, and coal; fuel derived from biologic material that was deposited into sedimentary rocks.

Frequency: The number of samples in which a plant or animal species occurs divided by the total number of samples.

Fugitive dust: Dust particles suspended randomly in the air, usually from road travel, excavation, and/or rock loading operations.

G

Game Management Unit (GMU): A geographic division made by the Alaska Department of Fish and Game for the management of fish and wildlife in the State. Different GMUs have different hunting and fishing seasons, bag limits, and other harvest rules.

Geology: The scientific study of the origin, history, and structure of the earth; the structure of a specific region of the earth's surface.

Geomorphic: Pertaining to the structure, origin, and development of the topographical features of the earth's crust.

Gill net: Nets made of one or more layers of mesh, used to catch fish by entanglement as they attempt to swim through the net.

Glacial drift: Unsorted sediments deposited by glaciers and not subsequently reworked by water; coarse-grained materials (e.g., rock and sand) suspended in a fine-grained (e.g., silt) matrix. The term applies to all mineral material transported by a glacier and deposited directly by or from the ice, or by running water emanating from a glacier.

Global warming: An increase over time of the average temperature of the earth's atmosphere and oceans. It is generally used to describe the temperature rise over the past century or so, and the effects of humans on the temperature.

Gray water: Discharge that includes wastewater from any or all of the following: kitchen sink, shower, drinking water, and laundry.

Greenhouse effect: A process by which thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases and is reradiated in all directions. Since part of this reradiation is back toward the earth's surface and the lower atmosphere, it results in an elevation of the average surface temperature above what it would be in the absence of the gases.

Greenhouse gas (GHG): A gas that absorbs and emits thermal radiation within the lowest layers of the atmosphere. This process is the fundamental cause of the greenhouse effect. The primary greenhouse gases that are considered air pollutants are carbon dioxide, (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs).

Groundwater: Water found beneath the land surface in the zone of saturation below the water table.

H

Habitat: The natural environment of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting living conditions. The place where an organism lives.

Hazardous air pollutants (HAPs): (also known as toxic air pollutants) Those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. The

Environmental Protection Agency (EPA) is required to control 187 hazardous air pollutants. Examples of HAPs include benzene (found in gasoline), perchlorethlyene (emitted from dry cleaning facilities), and methylene chloride (used as a solvent).

Hazardous waste: As defined by the Environmental Protection Agency, a waste that exhibits one or more of the following characteristics: ignitability, corrosivity, reactivity, and/or toxicity. Hazardous wastes are listed in 40 CFR § 261.3 and 40 CFR § 171.8.

Headwaters: The upper reaches of a stream where the stream forms.

Hydrocarbon: A naturally occurring organic compound comprised of hydrogen and carbon. Hydrocarbons can occur in molecules as simple as methane (one carbon atom with four hydrogen atoms), but also as highly complex molecules, and can occur as gases, liquids, or solids. The molecules can have the shape of chains, branching chains, rings, or other structures. Petroleum is a complex mixture of hydrocarbons. The most common hydrocarbons are natural gas, oil, and coal.

Hydrologic system: The combination of all physical factors, such as precipitation, stream flow, snowmelt, and groundwater that affect the hydrology of a specific area.

I

Impermeable: Not permitting passage of fluids through its mass.

Impoundment: The collection and confinement, usually of water (in the case of mining, tailings materials), in a reservoir or other storage area.

Increment: An amount of change from an existing concentration or amount, such as air pollutant concentrations.

Indigenous: Having originated in and being produced, growing, living, or occurring naturally in a particular region or environment.

Indirect impacts: Impacts that are caused by an action, but are later in time or farther removed in distance, although still reasonably foreseeable.

Infrastructure: The underlying foundation or basic framework; substructure of a community (i.e., schools, police, fire services, hospitals, water, and sewer systems).

Insect-relief area: An area of the North Slope with relatively low numbers of insects that is used by caribou for relief from insects.

Interstitial ice: Ice found in cavities or lodged between soil grains or rock crevices.

Irretrievable: A term that applies to losses of production, harvest, or commitment of renewable natural resources. For example, some or all of the wildlife forage production from an area is irretrievably lost during the time an area is used as an oil or gas development site. If the use changes, forage production can be resumed. The production lost is irretrievable, but the act is not irreversible.

Irreversible: A term that applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity. Irreversible also includes loss of future options.

Isobath: Depth interval contour, as commonly mapped for lake or ocean bottoms.

J

Jurisdictional wetland: A wetland area delineated and identified by specific technical criteria, field indicators, and other information, for the purposes of public agency jurisdiction. The U.S. Army Corps of Engineers regulates “dredging and filling” activities associated with jurisdictional wetlands. Other federal agencies that can become involved with matters that concern jurisdictional wetlands include the U.S. Department of Interior’s Fish and Wildlife Service, the Environmental Protection Agency, and the Natural Resource Conservation Service.

L

Landfast ice: Stationary ice that is continuous with, and attached to, the shoreline and extends out into the waterbody.

Landform: Any physical, recognizable form or feature on the earth’s surface having a characteristic shape, which is produced by natural causes. Landforms provide an empirical description of similar portions of the earth’s surface.

Land management: The intentional process of planning, organizing, programming, coordinating, directing, and controlling land use actions.

Landscape: The sum total of the characteristics that distinguish a certain area on the earth’s surface from other areas; these characteristics are a result not only of natural forces, but also of human occupancy and use of the land. An area composed of interacting and interconnected patterns of habitats (ecosystems), which are repeated because of geology, landforms, soils, climate, biota, and human influences throughout the area.

Land status: The ownership status of lands.

Land use allocation: The assignment of a management emphasis to particular land areas with the purpose of achieving the goals and objectives of some specified use(s) (e.g., campgrounds, wilderness, logging, and mining).

Laterally discontinuous: Not continuous in the horizontal plane. For example, in an area with laterally discontinuous permafrost, the permafrost is not uniformly found across the entire area without interruption.

Lead: Long cracks in the ice, used by both whales and boats to travel through the water.

Liquid natural gas: Natural gas which has been liquefied by reducing its temperature to -260 °F at atmospheric pressure. It will remain as a liquid at -116 °F and 673 pounds per square inch above atmospheric pressure.

Listed species: Species that are listed as threatened or endangered under the Endangered Species Act of 1973 (as amended).

Long-term impacts: Impacts that normally result in permanent changes to the environment. An example is the loss of habitat due to development of a gravel pit. For each resource, the definition of long-term may vary.

M

Maktak: Eskimo delicacy consisting of the skin and the thin layer of subcutaneous fat of whales.

Management activity: A human activity imposed on a landscape for the purpose of harvesting, traversing, transporting, or replenishing natural resources.

Management area: An area delineated on the basis of management objective prescriptions.

Management concern: An issue, problem, or condition that influences the range of management practices identified in a planning process.

Management direction: A statement of multiple use and other goals and objectives, and the associated management prescriptions, standards, and guidelines for attaining them (36 CFR § 219.3).

Masu: A starchy tuber found in arctic and subarctic regions (vernacular is “Eskimo potato”).

Mean: A statistical value calculated by dividing the sum of a set of sample values by the number of samples. Also referred to as the arithmetic mean or average.

Migratory: Moving from place to place, daily or seasonally.

Mitigation: Steps taken to: (1) avoid an impact altogether by not taking a certain action or parts of an action; (2) minimize an impact by limiting the degree or magnitude of the action and its implementation; (3) rectify an impact by repairing, rehabilitating, or restoring the affected environment; (4) reduce or eliminate an impact over time by preserving and maintaining operations during the life of the action; and, (5) compensate for an impact by replacing or providing substitute resources or environments (40 CFR Part 1508.20).

Memorandum of Understanding (MOU): Usually documents an agreement reached among federal agencies.

N

National Environmental Policy Act (NEPA): An act declaring a national policy to encourage productive and enjoyable harmony between humankind and the environment; promote efforts to prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humanity; enrich the understanding of the ecological systems and natural resources important to the nation; and establish a Council on Environmental Quality.

Net present value (NPV): The difference between the discounted value (benefits) of all outputs to which monetary values or established market prices are assigned and the total discounted costs of managing the planning area.

National Pollutant Discharge Elimination System (NPDES): A program authorized by sections 318, 402, and 405 of the Clean Water Act, and implemented by regulations 40 CFR § 122. The NPDES program requires permits for the discharge of pollutants from any point source into waters of the United States.

No-Surface-Occupancy: An area that is open for mineral leasing but analysis has found that in order to protect other resource values, no surface occupancy is permitted for oil and gas facilities or infrastructure.

Non-Associated Gas: Gas in a reservoir having little or no crude oil.

NO_x: Mono-nitrogen oxides, including nitric oxide (NO) and nitrogen dioxide (NO_2). It is formed when naturally occurring atmospheric nitrogen and oxygen are combusted with fuels in automobiles, power plants, industrial processes, and home and office heating units.

O

Objective: A concise, time-specific statement of measurable planned results that respond to pre-established goals. An objective forms the basis for further planning to define the precise steps to be taken and the resources to be used to achieve identified goals.

Oiled: Having oil on skin, fur, or feathers after coming into contact with an oil spill.

Ozone: Form of oxygen found largely in the stratosphere; a product of the reaction between ultraviolet light and oxygen.

P

Particulates: Small particles suspended in the air, generally considered pollutants.

Pelagic: Pertaining to the ocean and especially to animals (typically marine mammals, birds, or fish) that live at the surface of the ocean away from the coast.

Per capita income: Total income divided by the total population.

Performance-based stipulation: A stipulation applied to a lease that provides a stated objective that must be met, along with requirements and guidelines, but provides some leeway as to how that objective can be met and maintained by the lessee; compare to prescriptive-based stipulation.

Permafrost: Permanently frozen ground.

Permanent oil and gas facilities: Production facilities, pipelines, roads, airstrips, production pads, docks, seawater treatment plants, and other structures associated with oil and gas production that occupy land for more than one winter season. Material sites and seasonal facilities, such as ice roads, are excluded, even when the pads are designed for use in successive winters.

Permeability: The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; a measure of the relative ease of fluid flow under unequal pressure.

Photoperiod: In reference to cycles of light and darkness, the length of time that uninterrupted light is present, generally the length of daylight in a given 24-hour period.

Physiographic province: A region having a particular pattern of relief features or land forms that differs significantly from that of adjacent regions (e.g., Arctic Coastal Plain).

Pingo: A low conical hill or mound forced up by hydrostatic pressure in an area underlain by permafrost and consisting of an outer layer of soil covering a core of solid ice. Pingos range from 6 to 160 meters in height.

Planning area: An administrative unit determined by the Bureau of Land Management based on resources and management issues.

Plant community: A vegetation complex, unique in its combination of plants, which occurs in particular locations under particular influences. A plant community is a reflection of integrated environmental influences on the site, such as soils, temperature, elevation, solar radiation, slope aspect, and precipitation.

Pollution: Human-caused or natural alteration of the physical, biological, and radiological integrity of water, air, or other aspects of the environment that produce undesired effects.

Polygon: A surface landform resulting from repeated freeze-thaw cycles common in permafrost areas. Polygons are bounded by troughs of ice or water and generally occur in networks that form regular geometric designs with multiple square sides of nearly equal lengths.

Polynyas: Non-linear openings in the sea ice.

Porosity: The ratio of the volume of void space in a material (e.g., sedimentary rock or sediments) to the volume of its mass.

Potable: Suitable, safe, or prepared for drinking, as in potable water.

Pot hunting: The removal or theft of artifacts from cultural resource sites by untrained individuals for profit and recreation.

Prescriptive-based stipulation: A stipulation applied to leases with exacting requirements applying to lessee activities; compare to performance-based stipulation.

Prevention of significant deterioration (PSD): A special permit procedure established in the Clean Air Act, as amended, used to ensure that economic growth occurs in a manner consistent with the protection of public health and preservation of air quality related values in national special interest areas.

Pristine: Pure, original, and uncontaminated.

Prospect: An area of exploration in which hydrocarbons have been predicted to exist in commercially recoverable quantities.

Public scoping: A process whereby the public is given the opportunity to provide oral or written comments about the influence of a project on an individual, the community, and/or the environment.

Pulse: A group of whales; the term is applied to whales migrating across the Chukchi and Beaufort seas, when there are more individuals in each pod of whales and more pods than usual.

Pyrogenic: Producing or produced by heat.

R

Raptor: Bird of prey; includes eagles, hawks, falcons, and owls.

Recharge: Absorption and addition of water into the zone of saturation.

Record of Decision (ROD): A document separate from, but associated with, an Environmental Impact Statement, which states the decision, identifies alternatives (specifying which were environmentally preferable), and states whether all practicable means to avoid environmental harm from the alternative have been adopted, and, if not, why not (40 CFR § 1505.2).

Recoverable reserves: Oil and gas reserves that may be recoverable by the application of technology, but not necessarily commercially recoverable.

Regulated air pollutants: Pollutants first set forth in the Clean Air Act (CAA) of 1970 and are the basis upon which the Federal government and state regulatory agencies have established emission thresholds and regulations. Regulated air pollutants include criteria air pollutants, hazardous air pollutants (HAPs), volatile organic compounds (VOCs), and greenhouse gases. The same pollutant may be regulated under more than one of the regulatory standards.

Reservoir (oil or gas): A subsurface body of rock having sufficient porosity and permeability to store and transmit fluids. Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system.

Resident: A species that is found in a particular habitat for a particular time period (e.g., winter resident or summer resident) as opposed to a species found only when passing through during migration.

Resource Management Plan (RMP): Comprehensive land management planning document prepared by and for the Bureau of Land Management's administered properties under requirements of the Federal Land Policy and Management Act. Bureau of Land Management lands in Alaska were exempted from this requirement.

Rideup: A raised-relief ice formation that is formed when a moving ice sheet is forced up and over other structures such as land or ice.

Riffles: Stream segments where the water is relatively shallow, current velocity is relatively high, and sediments are coarse; riffles are located in between areas of deeper, slower water (pools).

Rift zone: Zone of faulting where rocks are pulled apart.

Riparian: Occurring adjacent to streams and rivers and directly influenced by water. A riparian community is characterized by certain types of vegetation, soils, hydrology, and fauna and requires free or unbound water or conditions more moist than that normally found in the area.

Risked mean: The arithmetic average of all possible resource outcomes weighted by their probabilities. Risked (unconditional) estimates of resources such as oil or natural gas consider the possibility that the area may be devoid of those resources. Statistically, the risked mean may be determined through multiplication of the mean of a conditional distribution by the related probability of occurrence.

Rolligon: A brand name or make of wheeled vehicle that exerts low pressure on the ground, and is designed to travel across sensitive areas such as tundra with minimal disturbance.

S

Satellite field: An oil reserve located near an existing oil development, allowing shared use of the infrastructure.

Scenic River: River designation, under the Federal Wild and Scenic Rivers Program, on the basis of undisturbed and scenic character. Scenic rivers are given special management criteria by federal agencies.

Scoping process: A part of the National Environmental Policy Act process; early and open activities used to determine the scope and significance of the issues, and the range of actions, alternatives, and impacts to be considered in an Environmental Impact Statement (40 CFR § 1501.7).

Sediments: Unweathered geologic materials generally laid down by or within waterbodies; the rocks, sand, mud, silt, and clay at the bottom and along the edge of lakes, streams, and oceans.

Sensitive species: Plant or animal species that are susceptible or vulnerable to activity impacts or habitat alterations. Species that have appeared in the Federal Register as proposed for classification or are under consideration for official listing as endangered or threatened species.

Short-term impacts: Impacts occurring during project construction and operation, and normally ceasing upon project closure and reclamation. For each resource, the definition of short-term may vary.

Sidetrack well: A secondary well-bore drilled away from an original well-bore. A sidetracking operation may be done intentionally or may occur accidentally.

Significant: The description of an impact that exceeds a certain threshold level. Requires consideration of both context and intensity. The significance of an action must be analyzed in several contexts, such as society as a whole, and the affected region, interests, and locality. Intensity refers to the severity of impacts, which should weighted along with the likelihood of its occurrence.

SO_x: Sulfur oxides, including sulfur dioxide (SO_2). A product of vehicle tailpipe emissions.

Sociocultural: Of, relating to, or involving a combination of social and cultural factors.

Socioeconomic: Pertaining to, or signifying the combination or interaction of social and economic factors.

Soil horizon: A layer of soil material approximately parallel to the land surface that differs from adjacent genetically related layers in physical, chemical, and biological properties.

Solid waste: Garbage, refuse, and/or sludge produced during oil and gas exploration and development activities.

Spawning: Production, deposition, and fertilization of eggs by fish.

Special use permit: A permit issued under established laws and regulations to an individual, organization, or company for occupancy or use of federal or state lands for some special purpose.

Spill Prevention Control and Countermeasure Plan (SPCC): A plan that the Environmental Protection Agency requires to be on file within six months of project inception. It is a contingency plan for avoidance of, containment of, and response to spills or leaks of hazardous materials.

Spine road: The existing all-season gravel road connecting the oil and gas facilities at Kuparuk (Kuparuk Base Camp) with those at Prudhoe Bay (Prudhoe Bay Operations Center).

Standard: A model, example, or goal established by authority, custom, or general consent as a rule for the measurement of quantity, weight, extent, value, or quality.

Stipulation: A requirement or condition placed by the Bureau of Land Management on the leaseholder for operations the leaseholder might carry out within that lease. The Bureau of Land Management develops stipulations that apply to all future leases within the National Petroleum Reserve-Alaska.

Stratigraphic trap: An oil or gas reservoir in which the hydrocarbons are trapped because of a lateral change in the physical characteristics of the reservoir or a change in the lateral continuity of the rocks.

Strike: The act of throwing a darting gun harpoon with a black powder or penthrite bomb into a whale. A strike may or may not result in a dead whale, which may or may not result in a landed whale. The International Whaling Commission considers and counts the number of strikes and landed whales in their quota allocation to the U.S. government (and hence to the Alaska Eskimos). Unused strikes can be transferred to other individuals or groups harvesting whales.

Subsistence: Harvesting of plants and wildlife for food, clothing, and shelter. The attainment of most of one's material needs (e.g., food and clothing materials) from wild animals and plants.

T

Talik: An unfrozen section of ground found above, below, or within a layer of discontinuous permafrost. These layers can also be found beneath waterbodies in a layer of continuous permafrost.

Tectonic plate: A large, thin, relatively rigid plate that moves relative to other plates on the outer surface of the earth.

Terrestrial: Of or relating to the earth, soil, or land; inhabiting the earth or land.

Thermokarst: Land-surface configuration that results from the melting of ground ice in a region underlain by permafrost. In areas that have appreciable amounts of ice, small pits, valleys, and hummocks form when the ice melts and the ground settles unevenly.

Threatened species: A plant or animal species likely to become an endangered species throughout all or a significant portion of its range within the foreseeable future.

Total petroleum system: The combination of geologic components and processes necessary to generate and store hydrocarbons, including a mature source rock, migration pathway, reservoir rock, trap, and seal. Includes all the petroleum generated by related source rocks and resides in a volume of mappable rocks. Geologic processes act upon the petroleum system and control the generation, expulsion, migration, entrapment, and preservation of petroleum.

Traditional knowledge: An intimate understanding by indigenous peoples of their environment, which is grounded in a long-term relationship with the surrounding land, ocean, rivers, ice, and resources. This understanding includes knowledge of the anatomy, biology, and distribution of resources; animal behavior; seasons, weather, and climate; hydrology, sea ice, and currents; how ecosystems function; and the relationship between the environment and the local culture.

Transfer payment: Money given by the government to citizens, such as Social Security, welfare, and unemployment compensation.

Trophic system: The process and organisms that move food energy through the ecosystem, often termed a food chain.

Tundra: Level or undulating treeless plain characteristic of northern Arctic regions, consisting of black mucky soil with permanently frozen subsoil and a dense growth of mosses, lichens, dwarf herbs, and shrubs.

Turbidity: A measure of the amount of suspended sediment in water.

U

Unavailable: When referring to oil and gas leasing, unavailable lands would not be offered for oil and gas leasing.

Unconventional oil and gas: Reservoir oil and gas that is more difficult or less economical to extract, usually because the technology to reach them has not been developed fully, or is too expensive.

V

Volatile Organic Compounds (VOCs): A group of chemicals that react in the atmosphere with nitrogen oxides in the presence of sunlight and heat to form ozone. VOCs contribute significantly to photochemical smog production and certain health problems. Examples of VOCs are gasoline fumes and oil-based paints.

W

Waterflooding: The injection of water into geological reservoirs to maintain or increase pressure in the reservoir and thereby assist in the extraction of oil.

Water quality: The interaction between various parameters that determines the usability or non-usability of water for on-site and downstream uses. Major parameters that affect water quality include: temperature, turbidity, suspended sediment, conductivity, dissolved oxygen, pH, specific ions, discharge, and fecal coliform.

Wetlands (biological wetlands): Those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstance do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include habitats such as swamps, marshes, and bogs (see jurisdictional wetlands).

Wildcat play: An unproven and prospective area of oil and gas potential that is outside of existing oil- and gas-producing areas or zones.

Wilderness: Land designated by Congress as a component of the National Wilderness Preservation System. For an area to be considered for Wilderness designation it must be roadless and possess the characteristics required by section 2(c) of the Wilderness Act of 1964. These characteristics are: (1) naturalness—lands that are natural and primarily affected by the forces of nature; (2) roadless and having at least 5,000 acres of contiguous public lands; and (3) outstanding opportunities for solitude or primitive and unconfined types of recreation. In addition, areas may contain “supplemental values,” consisting of ecological, geological, or other features of scientific, educational, scenic, or historical importance.

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