National Aeronautics and Space Administration

Draft Environmental Impact Statement

Sounding Rockets Program at Poker Flat Research Range

Volume I

Executive Summary and Chapters 1-9

September 2012

In Cooperation with:
Bureau of Land Management
U.S. Fish and Wildlife Service
University of Alaska Fairbanks

www.nasa.gov

Photo Credit: *Craig Heinselman, SRI*

Cover image: *The February 18, 2012 launch of the Magnetosphere-Ionosphere Coupling in the Alfvén Resonator (MICA) sounding rocket mission from Poker Flat Research Range, Alaska.*

National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Reply to Attn of: 250.W September 2012

Dear Reader:

This is the Draft Environmental Impact Statement (DEIS) for NASA's Sounding Rockets Program at the Poker Flat Research Range (PFRR), Alaska. Prepared in accordance with the National Environmental Policy Act (NEPA), the DEIS evaluates the environmental consequences of five alternative means for continuing sounding rocket launches at PFRR.

This DEIS has been sent to you because public involvement is a very important part of the NEPA process. Please review and provide comments on the DEIS no later than sixty (60) days following the publication of the U.S. Environmental Protection Agency's Notice of Availability in the *Federal Register*. Once known, this date will be posted on the project website at:
http://sites.wff.nasa.gov/code250/pfrr_eis.html.

Comments should be as specific as possible and should address distinct aspects of the DEIS document, including alternatives or the adequacy of the environmental analysis. We will consider all comments received in preparing the Final EIS. However, please note that all public comments received, including commenter name and address, will be included in the publicly available project record. Should you, as an individual, wish that we withhold your name or contact information, please clearly state this at the beginning of your comments. We will honor your request to the extent allowed by law. However, we are unable to withhold the names or contact information for persons representing organizations, government agencies, or businesses.

Additionally, our project team will be hosting several public meetings in Alaska to discuss the DEIS with interested parties. We encourage you to attend a meeting to speak with members of our team and to learn more about sounding rockets at PFRR. As meeting times and locations are scheduled, notices will be posted on the project website and published in the *Federal Register* or local news media.

The DEIS is available for review online at **http://sites.wff.nasa.gov/code250/pfrr_eis.html**. You may also request a hard copy or compact disc.

All requests for copies of the DEIS and comments should be submitted by one of the following options:

Mail: NASA Wallops Flight Facility
PFRR EIS – Joshua Bundick, Manager
Mailstop: 250.W
Wallops Island, VA 23337

Email: Joshua.A.Bundick@nasa.gov
Fax: (757) 824-1819

If you have any questions regarding the DEIS, please call (757) 824-2319 or toll-free at (800) 521-3415. When using the toll-free number, please follow the menu options and enter the "pound sign (#)" followed by extension numbers "2319."

We look forward to hearing from you. Thank you for your participation in this process!

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DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE SOUNDING ROCKETS PROGRAM AT POKER FLAT RESEARCH RANGE

VOLUME 1

EXECUTIVE SUMMARY
AND
CHAPTERS 1 THROUGH 9

Sounding Rockets Program Office
National Aeronautics and Space Administration
Wallops Island, VA 23337

September 2012

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DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE SOUNDING ROCKETS PROGRAM AT POKER FLAT RESEARCH RANGE

LEAD AGENCY:	National Aeronautics and Space Administration
COOPERATING AGENCIES:	U.S. Bureau of Land Management U.S. Fish and Wildlife Service University of Alaska Fairbanks
POINT OF CONTACT FOR INFORMATION:	Joshua Bundick Lead, Environmental Planning NASA Wallops Flight Facility Wallops Island, VA 23337 (757) 824-2319 Joshua.A.Bundick@nasa.gov
DATE:	September 2012

ABSTRACT

This *Draft Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* has been prepared by the National Aeronautics and Space Administration (NASA) in accordance with the National Environmental Policy Act, as amended, to assist in the decisionmaking process for its Sounding Rockets Program (SRP) at Poker Flat Research Range (PFRR), Alaska.

The proposed action addressed in this *PFRR EIS* is the NASA SRP's continued use of PFRR. Sounding rockets launched from PFRR support the advancement of scientific knowledge of the Sun–Earth connection, the upper atmosphere, and global climate change. Since the late 1960s, NASA, other government agencies, and educational institutions have conducted suborbital rocket launches from PFRR; however, changes in the uses and designations of downrange lands have led to a greater focus on the location and recovery of hardware related to sounding rocket, including spent stages and payloads from past and future launches. Accordingly, this *PFRR EIS* focuses on alternative means for NASA to continue its operations at PFRR within an increasingly sensitive environmental context.

This *PFRR EIS* presents a description of SRP at PFRR; an overview of the affected environment at the launch site and within the flight corridor; and the potential environmental consequences associated with five alternatives under consideration, including the No Action Alternative.

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

This *Draft Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended **(42 U.S.C. 4321 *et seq.*)**; the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA **(40 CFR 1500** through **1508)**; and the National Aeronautics and Space Administration's (NASA's) NEPA policy and procedures **(14 CFR 1216.3)**. The purpose of this Draft Environmental Impact Statement (EIS) is to assist in the decisionmaking process concerning the NASA Sounding Rockets Program's (SRP's) continued use of the Poker Flat Research Range (PFRR), a facility owned by the University of Alaska (UAF) east of Fairbanks, Alaska. The U.S. Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and UAF have served as cooperating agencies in the preparation of this *PFRR EIS* as they have either legal jurisdiction or special expertise regarding the alternatives under consideration.

ES. 1. BACKGROUND

Since the late 1960s, NASA, other government agencies, and educational institutions have conducted suborbital rocket launches from PFRR. While PFRR is owned and managed by the Geophysical Institute of UAF, NASA SRP has exclusively funded and managed the support contract with PFRR for more than 25 years. NASA recently reviewed its 2000 *Final Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* and determined that the overall environmental analysis in the 2000 *SRP SEIS* remains sufficient to support NASA's broad programmatic decision to continue the SRP; however, potential changes in both PFRR operations and the environmental context of the launch corridor north of PFRR warrant preparation of additional PFRR-specific environmental analysis. This *PFRR EIS* tiers from the 2000 *SRP SEIS*.

ES. 2. PURPOSE AND NEED FOR ACTION

NASA's purpose for action is to enable the continued safe and cost-effective sounding rocket-based scientific investigations at PFRR. Sounding rockets launched from PFRR support the advancement of scientific knowledge of the Sun–Earth connection, the upper atmosphere, and global climate change.

The proposed action is needed to ensure that NASA and the global science community have a launch capability based in the United States to conduct experiments to aid in the understanding of the phenomena affecting the past, present, and future of the Earth and the Sun–Earth connection. Sounding rockets permit the only means to study the lower atmosphere (40–80 kilometers [25–50 miles]) and the middle ionosphere (80–150 kilometers [50–93 miles]) with direct measurements, and the only means to explore the upper ionosphere (150–1,500 kilometers [93–930 miles]) with vertical trajectories on relatively slowly moving platforms. These are essential regions of the Earth's environment and must be measured to understand how the Earth and space interact.

The northern location of PFRR is strategic for launching NASA sounding rockets for scientific research in auroral space physics and earth science. PFRR is the only high-latitude, auroral-zone rocket launching facility in the United States where a sounding rocket can readily study the aurora borealis and the Sun–Earth connection.

ES. 3. ALTERNATIVES EVALUATED

This *PFRR EIS* evaluates five alternatives, including the No Action Alternative.

Elements Common to All Alternatives

Under all five alternatives, NASA would continue to fund UAF's PFRR and conduct scientific investigations using sounding rockets. NASA forecasts that an average of about four launches per year would be conducted at PFRR, but could range up to eight launches per year. This launch rate is typical of past years, but, because of the very nature of scientific research and discovery, it is not possible to predict accurately what future needs might be. New discoveries or scientific needs might require more or fewer launches to accomplish NASA's scientific goals.

Similarly, past scientific research has mandated that most launches be conducted during the winter months, with most of the launches occurring at night or in darkness. While this is the expected mode of future operations, new scientific needs might raise the desirability of other launch periods. If such needs were to arise, additional analysis of the range safety requirements, as well as potential mitigation factors to reduce environmental impacts, would be required.

No Action Alternative

Under this alternative, no significant efforts would be taken to recover spent stages unless desired for programmatic reasons, and payloads would only be recovered if required by the scientists. Thus, recovery efforts and impacts would primarily be focused on retrieval activities associated with recovery of parachuted payloads.

Alternative 1 (Environmentally Responsible Search and Recovery)

Under Alternative 1, NASA and UAF would employ enhanced efforts to locate new and existing spent stages and payloads within the PFRR flight corridor. Attempts would be made to recover all newly expended stages and payloads predicted to land on Federal, state, or private lands. Spent stages and payloads that are located would be recovered if it is determined that the recovery operation can be performed safely while causing minimal environmental damage. As such, some items or parts thereof could be left in the field if the landowners agree that attempted recovery could cause more damage to the environment than leaving it in place. A key component of this alternative is the development of a formal rocket hardware Recovery Plan.

For past SRP operations at PFRR, most spent rocket stages and payloads have not been recovered. Consistent with the philosophy that would be employed for new rocket motors and payloads, hardware that is located from past operations would be recovered if it could be done safely and in an environmentally responsible manner.

Alternative 2 (Maximum Cleanup Search and Recovery)

Alternative 2 is the same as Alternative 1, except maximum practicable effort would be exerted to fully recover newly expended and existing spent stages and payloads from PFRR if it is determined that they can be recovered safely, even if the efforts result in longer-term recovery-related environmental impacts. The key difference under this alternative compared to Alternative 1 is that NASA would also implement a policy that follows the mantra of "Leave No Trace Behind." Such a cleanup effort might require the use of larger equipment in remote areas, resulting in more short- and long-term disruption, but it is possible that the long-term benefits of removing outwardly visible hardware could outweigh those associated with a more intensive recovery effort.

Alternative 3 (Environmentally Responsible Search and Recovery with Restricted Trajectories)

Alternative 3 is the same as Alternative 1, except trajectories of future sounding rocket missions would be restricted such that planned impacts would not be permitted within designated Wild and Scenic River corridors. The restriction would be an extension of the existing prohibition on having planned impacts within Mollie Beattie Wilderness Area and would become a program requirement that must be met during mission planning. The restriction on planned impacts within Mollie Beattie Wilderness Area would remain in effect.

Alternative 4 (Maximum Cleanup Search and Recovery with Restricted Trajectories)

Alternative 4 would be the same as Alternative 2, except that like Alternative 3, NASA would restrict the flight trajectories of future PFRR missions such that planned impacts would not be located within Wild and Scenic River corridors or Mollie Beattie Wilderness Area.

Alternatives Considered but Dismissed from Detailed Study

NASA also considered additional alternatives but did not evaluate them in detail due to their inability to meet its purpose and need, largely due to an inability to achieve scientific goals, safety concerns, exorbitant cost, or a combination of the three. These alternatives included discontinuing operations at PFRR, relocating operations to other high-latitude launch sites, both foreign and domestic, use of other scientific platforms, installing recovery systems on all future missions, assigning numerical risk criteria to sensitive environmental features, launching easterly into Canada, and tracking all future stages and payloads.

ES. 4. ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES

This section summarizes the potential impacts on resources under the five *PFRR EIS* alternatives. Detailed descriptions and in-depth discussions of impacts on resources are provided in Chapter 4, "Environmental Consequences."

Project-related environmental impacts are described by their type, context, intensity, and duration for each affected resource area. The levels of impacts and their specific definitions vary based on the resource that is evaluated. **Table ES–1** provides a general overview of how potential impacts are evaluated in this EIS. Specific considerations that are only applicable to a resource area are described within its respective section in Chapter 4.

Table ES–1. Evaluation Criteria for Analyzing Environmental Impacts

Type of Impact	
Adverse	The impact would result in some level of environmental degradation.
Beneficial	The impact would result in some level of environmental improvement.
Context of Impact	
Local	The impact would not extend beyond the immediate vicinity of the action causing the effect.
Regional	The impact would occur over a larger geographic scale, such as an ecoregion.
Global	The impact would occur at the global level.
Intensity of Impact (how much)	
Major	Substantial impact on or change in a resource area that is easily defined, noticeable, and/or calculable but may not be measurable, or exceeds a threshold level that may threaten the integrity of one or more resource components.
Moderate	Noticeable change in a resource occurs, but the integrity of the resource remains intact.
Minor	The impact is at the lowest levels of detection (barely measurable and with no perceptible consequences) or would result in only a minor change in a resource.
Negligible	Impact is at the lowest level of measurement or is so low as to be immeasurable and has no perceptible consequences.
Duration of Impact (how long)	
Long-Term	The impact would likely persist for a period greater than the medium-term impact and, depending on the specific resource and project type, would likely extend beyond the life of the project.
Medium-Term	The impact would only occur for specific, relatively brief periods during the project life, interrupted by periods of no impacts (for example, during recovery operations).
Short-Term	The impact would extend for short periods much less than the overall project life (for example, during launch operations).

Potential impacts on resource areas are presented in a comparative format such that the reader can best understand how each compares to the next. A *relative comparison* is provided, and compares the impacts from one alternative to the others. Additionally, an *absolute description* of the impact, consistent with the findings in Chapter 4, is provided so that the reader can understand how each alternative affects the resource area in “the bigger picture.” For example, even if one alternative may result in greater impacts on a resource than another alternative, if those greater impacts do not represent a substantial overall difference (*i.e.*, both are still considered minor) in potential effects, it may not need to be a key driver in NASA’s final decision.

For all resource areas, a general discussion of potential impacts occurring from non-winter launches is presented. Although non-winter launches have not occurred within recent years, and are not expected to occur, the potential for their proposal cannot be completely discounted. Therefore, a high-level assessment of potential effects and necessary considerations is provided as a means to identify relevant issues that would need to be addressed should the need for such an operation arise. Given only the cursory level of assessment of potential effects in this EIS, any future proposals for non-winter launches would require more-focused, mission-specific NEPA analysis, as appropriate.

Air Quality

Air quality impacts from PFRR routine operations (*e.g.*, facility heating, employee transportation) would be equal for all alternatives, regional in scope, and adverse, but minor and long-term in duration. Impacts from rocket launches would also be the same for all alternatives and global in scope, adverse, and minor and short-term in duration. The No Action Alternative would have the least air quality impacts from search and recovery operations, followed by Alternatives 1 and 3. Alternatives 2 and 4 would result in the greatest possible impacts. However, in absolute terms, search and recovery-related impacts for all alternatives would be regional in scope and adverse, but minor and medium-term in duration. Impacts from non-winter launches would not be expected to be measurably different from those described above under any of the five alternatives.

Global Atmosphere

For all alternatives, emissions from rocket launches would be equal and confined to the lower layers of the atmosphere. It is expected that there may be a very small, temporary, local stratospheric ozone reduction effect in the wake of upper-stage rockets, but no globally noticeable effects (minor, long-term impacts).

The No Action Alternative would have the least air quality impacts from search and recovery operations, followed by Alternatives 1 and 3. Alternatives 2 and 4 would result in the greatest possible impacts because additional search and recovery activities would be undertaken. However, in absolute terms, search and recovery-related greenhouse gas emissions and resulting impacts on climate change would be global, adverse, minor, and long-term. Impacts from non-winter launches would not be expected to be measurably different from those described above under any of the five alternatives.

Water Resources

For all alternatives, it is expected that the potential adverse impacts from launches and reentry of flight hardware on surface water quality would be equal. As compared to the No Action Alternative, additional recovery-related surface disturbance would occur under Alternatives 1 and 3 and 2 and 4, potentially increasing the likelihood for sediment-laden runoff to enter surface waters. The risk of spills from recovery equipment would also increase; however, the additional adverse impacts on surface water or groundwater resources beyond the localized, negligible, and short-term effects of the No Action Alternative would be minor. For all alternatives, impacts on groundwater or perennial spring water quality or recharge are also anticipated to be negligible.

The restricted trajectories proposed by Alternatives 3 and 4 would be the least impactful on designated Wild Rivers in that they could lessen the already low probabilities that spent stages or payloads would land within them. Alternatives 1 and 2, respectively, would have the next greatest impacts, as they would entail the removal of items if located. Impacts would be greatest for the No Action Alternative, as no flight hardware would be removed unless required for scientific evaluation. However, for all alternatives, adverse effects on the physical and chemical integrity of designated Wild Rivers are anticipated to be localized, negligible, and short-term. Potential effects of other Wild River values, particularly recreation and wilderness experience, are discussed under Land Use and Recreation.

Compared to winter conditions, interaction of flight hardware with surface water or groundwater resources would be more immediate in the case of a non-winter launch. However, the principles and patterns of possible water resource impacts would follow similar trends and ultimate endpoints.

Geology and Soils

For all alternatives, impacts from launch and reentry of flight hardware are expected to be the same. Under winter snow, ice cover, and frozen soil conditions, no soil erosion impacts or degradation of permafrost is expected. No impacts on PFRR launch site or launch corridor soil chemistry are anticipated from the corrosion of metal items. Based on the relatively low number of flights, small payload quantities, relatively small ground area that would be affected, and low levels and decomposition rates of perchlorate in the soil, adverse impacts on soil chemistry would be short-term, negligible, and localized. Negligible adverse impacts on soil chemistry are anticipated, and adverse impacts on soil erosion would be minor in magnitude and medium-term in duration.

Under Alternatives 1 and 3, the additional efforts to recover flight hardware could result in isolated soil disturbances from activities such as hand-digging around a landing site; however, all recovery efforts would be conducted in an environmentally sensitive manner, thereby mitigating the impact to a level that is essentially equivalent to the No Action Alternative. Although Alternatives 2 and 4 would entail the greatest recovery efforts and could result in potentially the greatest soil disturbances, the extent of impacts beyond those effects expected for the other alternatives would be minor.

Compared to winter conditions, interaction of flight hardware with soil resources would be more immediate because there would not be as much snow and ice on the surface to cushion the impact of spent stages or payloads. However, the principles and patterns of possible soil-related impacts would follow the same trends and ultimate endpoints. Indirect impacts could result from the increased likelihood of a wildfire starting as a result of a spent stage igniting such a fire. Under such circumstances, before a summer launch was conducted, additional precautions would be necessary to minimize the risks associated with igniting such a fire, including notifying appropriate fire patrol personnel.

Noise

For all alternatives, the continued launch of sounding rockets would be equal to and consistent with existing sources of noises at PFRR. In absolute terms, the noise impact from routine PFRR activities, employee vehicles, and delivery vehicles under all alternatives would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

Search and recovery-related noise would be the least under the No Action Alternative and would be considered adverse, regional in scope, medium-term, and minor. Estimates of noise levels on the ground under search and recovery aircraft would be similar for all alternatives. Sound levels generated from disassembly of rocket motors during recovery would likely be above background levels within the downrange lands; however, in either scenario, the sound generated would be short-term (*i.e.*, generally less than an hour per motor), infrequent, and depending on specific conditions, confined to a limited distance from the source. Accordingly, the noise impact from search and recovery operations under Alternatives 2 and 4 would be the greatest of the alternatives and considered regional in scope, adverse, medium-term in duration, and moderate in intensity.

The type, intensity, and duration of noise impacts would be the same for a non-winter launch; however, the likelihood of a receptor (*e.g.*, recreational user, wildlife species) hearing the sound of a rocket flight, reentry, and post-flight search would be greater. Potential impacts on these resources are discussed under Land Use and Recreation and Ecological Resources.

Visual Resources

Under all alternatives, no measurable changes would be made to the appearance of the PFRR launch site; therefore, no impacts on visual resources would be expected. The impact on visual resources from the launching of sounding rockets would be the same for all alternatives and would be minor and short-term.

The intensity of an alternative’s impact from land-impacting flight hardware would be dependent upon where the impact site is located and how often users of the downrange lands see it. For example, it is expected that an item landing in a regularly used Wild River corridor could result in greater adverse impacts on visual resources than an item that is partially buried in a remote bog. The duration of impacts on visual resources would vary depending on how long the stages and payloads were left unrecovered.

The restricted trajectories proposed under Alternatives 3 and 4 could result in lower probabilities that future rocket launches from PFRR would impact in these areas. Since these areas may attract a greater number of visitors due to their designations, avoidance of these areas could result in fewer search and recovery actions within the areas and less potential adverse impacts on visual resources. Coupled with the commitment to search and recovery of located items, it is expected that Alternatives 3 and 4 would have the least long-term adverse effects on visual resources. However, the presence of search and recovery aircraft would result in a short-term, minor adverse effect. Additionally, under Alternative 4, a more aggressive cleanup policy could result in localized ground scars or ruts, which could degrade the natural appearance of an area.

Recovery of additional payloads and spent stages under Alternatives 1 and 2 would reduce the probability of a visitor or user of the lands encountering such materials, thereby reducing the long-term visual impact. However, no specific provisions would reduce the likelihood of planning an impact within a designated Wild River. Similar to Alternatives 3 and 4, the presence of search and recovery aircraft would result in a short-term, minor adverse effect. In general, few payloads (and even fewer stages) would be recovered under the No Action Alternative. Accordingly, adverse impacts on visual resources would be the greatest under the No Action Alternative and would most likely be long-term and could range from minor to moderate, depending on location.

No change in BLM Visual Resource Management classification would be anticipated for the lands within the PFRR launch corridor under any of the five alternatives.

As more human activities would occur within the PFRR launch corridor during non-winter months, the potential for someone to observe a rocket overflight would be greater. Also, due to the absence of frozen ground and ice during the summer in areas of lower elevation, there is the potential that spent stages would bury themselves in shallow bogs and sloughs (particularly in the wetland areas of the Yukon Flats), thereby lessening the likelihood of a land user encountering such materials. Additionally, there is the potential that a land user would observe a post-launch fixed-wing search operation within the PFRR launch corridor due to the larger user base during the non-winter months.

Ecological Resources

Under all alternatives, there would be no impacts on vegetation at the launch site because the surrounding area is cleared and maintained free of vegetation. Upon landing of flight hardware, impacts on vegetation would be restricted to the area immediately surrounding the item(s) and would diminish rapidly as distance from the impact point increases. Therefore, potential adverse effects on vegetation and habitat under all alternatives from launch and impact of flight hardware would be equal and local in scope, short-term in duration, and negligible in intensity. Any adverse impacts from launch operations on wildlife (*e.g.*, direct strike, startle) would be similar for all alternatives and would be local, short-term, and negligible due to the time of year that launches typically occur (winter months), the low density of species within the launch corridor, and the infrequency of launches during a launch season (average of four per year).

Impacts on vegetation from recovery operations would be the least under the No Action Alternative. The additional recovery efforts under Alternatives 1–4 would add to the areal extent of disturbance to vegetation, although the types of disturbance would be the same as those described under the No Action Alternative. Because of the low number of recovery efforts annually, the small and isolated area of vegetation affected by recovery of a spent stage or payload, and the natural regeneration of vegetation after disturbance, adverse impacts on vegetation would also be negligible under Alternatives 1–4.

It is expected that recovery-related impacts (*e.g.*, startle) on wildlife species would be the least under the No Action Alternative. The additional recovery efforts under Alternatives 1 and 2 would increase the potential for disturbance of terrestrial wildlife and birds; however, any adverse impacts would be localized to the vicinity of search and recovery activities, would be short-term in duration, and would be minor.

The restricted trajectories provided under Alternatives 3 and 4 could lessen the potential impacts on wildlife within these areas. However, any adverse impacts on wildlife are already considered to be negligible, so any decrease in impacts is not expected to be substantial.

None of the five alternatives would adversely affect essential fish habitat, target species, or subsistence species. Due to the presence of federally listed species within the launch corridor, NASA is consulting with USFWS and the National Oceanic and Atmospheric Administration Fisheries Service regarding potential effects of its operations at PFRR on listed, proposed, and candidate species under their respective jurisdictions. There are no listed, proposed, or candidate species known to live in the vicinity of the PFRR launch site or under the launch corridor until it approaches the coast of the Beaufort Sea. The ringed seal (proposed threatened) and the polar bear (threatened) have the potential to occur year-round within the region of influence (ROI) and could be affected by descending payloads or spent stages. The bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate) are summer residents and would be absent during the winter season, when launches are proposed to occur and payloads and spent stages are expected to impact sea ice covering the Beaufort Sea. Spectacled and Steller's eiders (threatened) are accidental in occurrence and uncommon within the ROI. They would also most likely be present during the summer months, if they were present at all.

In the event of a non-winter launch, more vegetation would be exposed due to a lack of snow cover; therefore, impacts would be greater. Additionally, the risk of unintentional wildfire from hot reentering flight hardware would increase markedly. Spent stages and payloads would have greater potential to land in proximity to wildlife than during winter because of the greater number of species present, potentially causing short-term behavioral response such as flight. Responses to search and recovery activities would be negligible, since these activities would normally occur during summer under any launch scenario. The likelihood of direct impacts on fish of importance for subsistence or commerce fisheries is expected to be minimal. The potential impacts on federally listed species would need to be revisited, as more species would be located within the PFRR launch corridor during non-winter months.

Land Use and Recreation

The most recent USFWS- and BLM-issued permits for rocket landing and recovery within the Yukon Flats and Arctic National Wildlife Refuges (NWRs) require the recovery of flight hardware. Therefore, the No Action Alternative, which would direct recovery of payloads solely for scientific need, would not be fully consistent with the terms and conditions of the use permits, and would likely not by authorized by the land management agencies.

The No Action Alternative would not limit the ability for users to visit or take part in recreational activities within downrange lands; however, it would result in the greatest deposition of flight hardware in downrange lands. In the case that recreational users of the downrange lands were to discover a piece of flight hardware, it could negatively affect their experience, particularly those persons intending to have a wilderness experience. Others may find it a positive experience to discover a spent stage or payload. It is expected that those persons engaged in hiking and rafting would be the most sensitive to finding sounding rocket hardware, with hunters, trappers, and snow machines the most tolerant. The impact would be on a person-by-person basis and would be influenced by the perception of the individual. Accordingly, impacts could be beneficial or adverse, localized, minor in intensity, and short-term to long-term in duration, depending on how long the known payloads and spent stages remain within the launch corridor.

Recovery of payloads and new and existing spent stages under Alternative 1 would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with BLM, USFWS, and landowners within the ROI. Additionally, it would reduce the probability that a recreational user would encounter flight hardware. However, as compared to the No Action Alternative, initial search activities could have negligible, short-term impacts on persons participating in recreational activities in areas within the PFRR launch corridor. Given the relative infrequency of flights and the very low probability that a low-flying/landing recovery action would be necessary within the most highly used river corridors within the downrange lands, adverse effects are anticipated to be localized, minor in intensity, and short-term in duration. It is expected that in most cases, the long-term impacts of leaving a piece of flight hardware within the downrange lands would be greater than the short-term disturbances (*e.g.*, noise, aircraft overflight) associated with recovery.

Land use and recreation impacts from launches under Alternative 2 would be essentially the same as Alternative 1. Recovery of the additional payloads and new and existing spent stages would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with the landowners within the ROI. However, under this alternative, it is possible that some outward signs of more invasive recovery operations could be exhibited, affecting the wilderness character of the lands. Additionally, more recovery flights could result in more recreational users observing aircraft overhead.

Impacts on land use and recreation under Alternatives 3 and 4 would be identical to those identified under Alternatives 1 and 2, respectively, with the exception of NASA's restricting trajectories on future launches such that designated Wild or Scenic River segments would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could reduce the probability that spent stages or payloads would land within these areas and therefore reduce the need to recover spent stages or payloads from these areas.

For non-winter launches, it is expected that impacts on land use and recreation would be greater due to the larger user base in downrange lands. It is possible that more visitors would voluntarily suspend or relocate their planned activities upon reading posted launch notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. It is also possible that downrange "clear" zones would need to be established to ensure public safety, thereby restricting public access to these areas. However, in the event that such an operation would be proposed, substantial early coordination with downrange landowners would be required to reduce potential impacts to the greatest extent practicable.

Cultural Resources

For all alternatives, under the anticipated launch schedule of an average of four launches annually, there is an extremely low probability of impacting or damaging a specific site of cultural or religious importance. Launches during the winter would likely reduce the potential impact if a landing was to occur on a cultural resource, as snow and ice and frozen ground would reduce surface and subsurface damage. To date, no impacts on cultural resources have been documented through the existing SRP launch and limited recovery program. NASA would continue to coordinate with agencies and Alaska Natives according to Section 106 of the National Historic Preservation Act, NASA regulations, and other pertinent laws and regulations, as appropriate.

Due to its limited recovery activities, the No Action Alternative would be expected to have the least recovery-related chance of impacting an area of cultural significance. Because there would be a greater number of recovery activities under Alternatives 1 and 4 compared to the No Action Alternative, there would be a greater possibility of disturbing a historic property. In relative terms, Alternatives 2 and 4, which would entail the greatest recovery effort, could present the highest risk of resource damage. However, given the low probability of landing on or adjacent to such a resource (and then becoming a recovery site), it is expected that impacts from recovery would also be negligible for all alternatives.

For non-winter launches, the impact point could experience greater effect if the ground were thawed than during the winter, when the ground is frozen. If the impact point were to be on or very near a cultural resource, and if that resource were a historic property, this could have a greater effect than during the winter. However, the likelihood of a rocket impacting a historic property is extremely low; thus, it is unlikely that summer launches would adversely impact historic properties.

Subsistence Resources

Under all alternatives, the chances of a direct impact on subsistence resources within the PFRR launch corridor due to a payload or spent stage striking an individual animal are negligible. Therefore, adverse effects on subsistence activities would also be negligible to minor and short-term.

The potential for recovery-related impacts on subsistence users would be the least under the No Action Alternative. The villages of Arctic Village, Beaver, Fort Yukon, Stevens Village, and Venetie have subsistence use areas within or in close proximity to the predicted impact areas for spent stages and payloads that would be removed under Alternatives 1 and 2. Noise from low-flying aircraft would have the potential to startle wildlife and could cause the wildlife to leave the area in which search and recovery operations are taking place. However, these startle effects and departures from the area are expected to be temporary and limited to the relatively short periods that these aircraft would be within earshot of or visible to wildlife. Once any disturbance from the low-flying aircraft has ceased, it is expected that wildlife would return to their normal habits and locations. Any adverse impacts on subsistence resources or the harvest of subsistence resources are expected to be localized, minor, and short-term in duration under Alternative 1.

Although Alternative 2 has the potential for the greatest disturbance to wildlife and subsistence hunting, these activities would continue to be relatively minor and infrequent across the affected areas since they would be spread over great distances. The restricted trajectories proposed under Alternatives 3 and 4 would not be expected to have measurable differences in potential impact on subsistence resources or uses and would therefore be equivalent to Alternatives 1 and 2.

For non-winter launches, greater potential impacts on subsistence activities would be expected due to the larger presence of subsistence resources in downrange lands and waters. As discussed under Ecological Resources, direct impacts on fish and game resources would be minor. However, as discussed under Health and Safety, requirements to maintain public safety could result in areas being avoided (either voluntarily or mandatorily) by subsistence users who would otherwise be hunting or fishing.

It should be noted that the impacts would be launch-specific and highly dependent upon the month it would occur. For example, a launch planned in late spring or early summer could affect subsistence hunters targeting waterfowl on the Yukon Flats, whereas a mid-summer launch would require consideration of traditional fishing camps along the many rivers within the ROI. Consultation with Alaska Natives and downrange landowners would be necessary for NASA and PFRR to assess the potential effects of a specific non-winter launch and appropriately mitigate its potential effects.

Transportation

Under all alternatives, the estimated number of traffic fatalities associated with truck transports would be minor, with a risk of about 1 chance in 500 years that a traffic fatality would occur. The impact on traffic volume of truck transports related to launch and search and recovery operations would be negligible.

The risk of an air transport incident under the No Action Alternative is estimated to be the least of the alternatives, with a risk of about 1 chance in 4,800 years that a fatal accident would occur. Alternatives 1 and 2 would result in greater risk, at 1 chance in 770 years and 1 chance in 480 years, respectively, due to more flight time during recovery operations. These probabilities are very low and would be considered negligible and minor impacts, respectively. The restricted trajectories proposed under Alternatives 3 and 4 would not change the potential transportation impacts as compared to Alternatives 1 and 2.

For a non-winter launch, the transportation impacts should remain the same as those projected for launch operations in the winter because the truck transports and aircraft operations associated with search and recovery activities would occur during the summer under either launch scenario.

Waste Management

Under all alternatives, future launch activity would remain at a level similar to what has occurred at PFRR in the past 10 years. The continuation of launch operations would require the use of small quantities of potentially hazardous materials, some of which would unavoidably land within downrange properties. These materials typically include small pyrotechnic devices, rechargeable batteries, compressed gases, lead-containing solder and balance weights, chemical tracers, and (for some older rocket motors) asbestos-containing insulation. In comparison to the structural materials (*e.g.,* hardened steel, aluminum) of sounding rocket hardware, these potentially hazardous components make up a very small portion of the total mass of a spent stage or payload.

A key difference among the alternatives is the amount of material that NASA would remove from downrange lands. Under the No Action Alternative, an estimated average of 2,800 kilograms (6,200 pounds) of recoverable spent stages and payloads would be deposited in lands outside the Poker Flat North and South Special Use Areas annually. Of this material, between approximately 2,200 kilograms (4,850 pounds) and 3,400 kilograms (7,500 pounds) would be expected to land within the Alaska Department of Natural Resources (ADNR) Poker Flat North and South Special Use Areas, thus resulting in a net deposition of between 1,200 kilograms (2,650 pounds) and 2,400 kilograms (5,300 pounds) elsewhere, a ***moderate to major long-term adverse impact.***

Under Alternative 1, approximately 900 to 2,300 kilograms (2,000 to 5,100 pounds) of material would be deposited in downrange lands annually under this alternative. Excluding the materials within the designated ADNR Poker Flat North and South lands, other downrange lands could realize a net reduction of 500 kilograms (1,100 pounds) up to and 900 kilograms (1,980 pounds) increase in materials, which would correspond to either a minor beneficial to minor adverse long-term impact of regional scope.

Under Alternative 2, up to a 900-kilogram (2,000-pound) overall reduction in waste could occur, however up to 400 kilograms (880 pounds) of material could be deposited in downrange lands annually under this alternative. Excluding the items within the designated ADNR Poker Flat North and South lands, other downrange lands could realize a net reduction of 1,200 kilograms (2,650 pounds) up to a 100-kilogram (220-pound) increase in materials, which would correspond to either a moderate beneficial to minor adverse long-term impact of regional scope.

The restricted trajectories proposed under Alternatives 3 and 4 would not change the potential quantities of wastes deposited in downrange lands as compared to those described for Alternative 1 and 2. They could, however, reduce the potential for such materials to land within the avoided areas. No change in hazardous material and waste use or generation or its impact on the environment is anticipated in the event of a summer launch.

Health and Safety

Under all alternatives, public and worker health and safety impacts associated with the launch of NASA sounding rockets from PFRR would be equal, short-term, and negligible. Health risks to workers and recovery personnel occur principally during the short period around the launch when the rocket is being prepared and when the search and recovery activities take place. Continued adherence to the NASA safety rules should ensure that the risk to the PFRR workers and visitors would remain very low with future missions. The public is protected from the impacts of sounding rockets and their components through the safety policies and practices of the NASA SRP. All NASA SRP missions are required to prepare both Ground and Flight Safety

Plans to minimize risk to human life and property. A Flight Safety Risk Assessment is also prepared for each mission. Both impact and overflight criteria are considered in the Flight Safety Plans and, while risk cannot be entirely eliminated, it is reduced to an acceptable margin. The criteria that are imposed are a combination of NASA criteria from NASA's *Range Safety Manual* that is common across the U.S. Government rocket launch ranges, and additional criteria or guidelines adopted by UAF and PFRR. In most cases, these criteria are acceptance criteria, and nominally less restrictive risk estimates may be approved on a case-by-case basis with recognition of the conservatism built into the risk calculations.

Based on the assumed recovery of 1 payload per year under the No Action Alternative and normal injury and fatality rates for similar types of activities in Alaska, no annual fatal injury flight accidents, no occupational injuries during ground recovery operations, and no fatalities during ground recovery activities would be expected. Projected impacts of search and recovery of the assumed 2 payloads and 10 stages under Alternative 1 are about a factor of 6.4 to 9 times higher than the No Action Alternative, but are still small, with no lost work day injuries or fatalities expected during a year's recovery operations. Projected impacts from search and recovery of the assumed 4 payloads and 16 stages under Alternative 2 are the highest at a factor of 11 to 19 times higher than the No Action Alternative, but again are still small, with no lost work day injuries or fatalities expected. Alternatives 3 and 4 would be expected to have the same potential impacts as Alternatives 1 and 2, respectively.

The potential safety risks would be higher for non-winter launches due to higher population densities and greater potential for unintended impacts due to accidents, including fires started by incompletely burned stages. Burning solid propellant and hot rocket motors could produce fires in areas of impact. This would be especially true where impacts occurred in dry areas during the summer months. The potential worker risks would be unchanged or slightly less for summer launches because workers would not be subject to the below freezing temperatures present at PFRR during the winter months. Before scheduling a summer launch, additional landowner consultation and safety analyses would need to be performed to ensure that such launches could be conducted safely in accordance with NASA, UAF, and landowner guidelines.

Socioeconomics and Environmental Justice

For all alternatives, normal operations at PFRR are estimated to result in direct employment of approximately 17 full-time equivalents annually. Direct employment at PFRR is expected to generate indirect employment of approximately 11 jobs, for a total impact of 28 jobs within the ROI attributable to PFRR activities. Normal operations at PFRR are estimated to generate approximately $1.9 million of direct economic activity annually. Approximately $1.4 million of the value added would be in the form of earnings to PFRR employees, which in turn would generate an estimated $640,000 of indirect earnings within the ROI, resulting in minor, medium-term, beneficial socioeconomic impacts.

Search and recovery activities under the No Action Alternative would be the least of the alternatives and would result in negligible, though beneficial, socioeconomic impacts over the medium-term. Additionally, the No Action Alternative is not expected to create any additional indirect employment opportunities. Under Alternatives 1 and 2, recovery activities are expected to result in minor, medium-term, beneficial effects, with the generation of 3 and 4 full-time jobs, respectively, with the annual value added to the local economy estimated to be approximately $166,000 and $282,000, respectively. The restricted trajectories proposed under Alternatives 3 and 4 would not change the potential socioeconomic impacts associated with Alternatives 1 and 2. Non-winter launches would not change the socioeconomic impacts projected for the different alternatives under consideration.

Regarding environmental justice, the analyses presented for each alternative have shown that the intensity of the risks to public health and safety from NASA SRP normal operations, off-normal flights, and transportation are estimated to be negligible to minor. In addition, continued SRP operations at PFRR, including search and recovery activities, are not expected to adversely affect subsistence resources or users within the PFRR launch corridor. Therefore, continued NASA SRP operations at PFRR are not expected to result in disproportionately high and adverse impacts on minority or low-income populations under any of the alternatives under consideration in this EIS.

Cumulative Effects

NASA considered a number of past, present, and reasonably foreseeable future actions that could occur on downrange lands and would contribute cumulatively to impacts on the same resource areas affected by PFRR launch and recovery. With the exception of waste, the cumulative effects analysis in this EIS indicates that the NASA SRP's operations at PFRR under any of the five alternatives would be much smaller in scope and environmental impact that other activities occurring within the ROI; therefore, its contribution to adverse cumulative effects would be minor.

Regarding cumulative waste, more than 40 years of PFRR operation with limited focus on recovery of flight hardware from both NASA and non-NASA launches has resulted in net deposition of approximately 181,000 kilograms (399,000 pounds) of items within the flight corridor (inland and ocean areas combined), with the majority of it being inert steel and aluminum. Approximately 45 percent of all items (approximately 64 percent by weight) are estimated to be located within the ADNR Poker Flat North and South Special Use Areas, which are specially designated for rocket and payload impacts.

Within other downrange lands, the No Action Alternative would result in a continued cumulative increase in the deposition of flight hardware, resulting in a major, long-term, adverse impact. Accordingly, NASA has incorporated mitigation of this long-term adverse impact in Alternatives 1–4 by establishing a formal Recovery Program such that over time, the quantity of flight hardware would be reduced in downrange lands. Alternatives 1 and 3 would have lesser cumulative effects than the No Action Alternative; while Alternatives 2 and 4 would likely result in the most waste removed from downrange lands over time, and would likely contribute the least to long-term adverse cumulative effects.

ES. 5. MITIGATION MEASURES

All of the alternatives evaluated in detail in this EIS have the potential to produce impacts to one or more resource areas. Based on analysis in Chapter 4 of this EIS, only the No Action Alternative could potentially result in significant impacts on Land Use and Waste Management. NASA has included mitigation measures as integral components of Alternatives 1 though 4. These measures are described in detail in Chapter 2, Section 2.1.7.2, Chapter 4, Section 4.18, and in Appendix E.

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LIST OF ABBREVIATIONS AND ACRONYMS

∑	sigma, absolute dispersion
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AK	Alaska
Al	aluminum
ANILCA	Alaska National Interest Lands Conservation Act
BLM	U.S. Bureau of Land Management
C	carbon
Ca	calcium
CAA	Clean Air Act
CAAA	Clean Air Act and its Amendments
Cd	cadmium
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Cl	chlorine
Cm	curium
Co	cobalt
CO_2	carbon dioxide
Cu	copper
CWA	Clean Water Act
D	distance(s)
dBA	decibels A-weighted
DOD	U.S. Department of Defense
EA	Environmental Assessment(s)
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement(s)
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
ERD	Environmental Resources Document(s)
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FB	Fairbanks, Alaska
Fe	iron
FEIS	Final Environmental Impact Statement
FR	*Federal Register*
FY	fiscal year
GMU	Game Management Unit
GPS	global positioning system
GRN	Sondre Stromfjord, Greenland
GSFC	Goddard Space Flight Center
H	hydrogen
HANLC	high altitude noctilucent clouds

LIST OF ABBREVIATIONS AND ACRONYMS (*Continued*)

HFEF	high frequency electron flux
HMTA	Hazardous Material Transportation Act
HSWA	Hazardous and Solid Waste Act
IR	infrared
kg	kilogram(s)
km	kilometer(s)
kNm	kilo-Newton-meters
kPa	kilopascal(s)
KWAJ	Kwajalein, Marshall Islands
LC	launch complex(es)
Li	Lithium
LVI	launch vehicle impact
Mg	magnesium
MISTI	mesospheric ionization structure and turbulence investigation
mm	millimeter(s)
MMPA	Marine Mammals Protection Act
MOTR	Multi-Object Tracking Radar
MS	mass spectrometer
msl	mean sea level
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NCA	National Conservation Area
NEPA	National Environmental Policy Act
NHPA	*National Historic Preservation Act*
NMFS	*National Marine Fisheries Service*
NO_x	oxides of nitrogen
NPS	National Park Service
NRA	National Recreation Area
NRHP	National Register of Historic Places
NSROC	NASA Sounding Rocket Operations Contract
NWR	National Wildlife Refuge
OSHA	Occupational Safety and Health Administration
OSSA	Office of Space Science and Applications
Pb	lead
PFRR	Poker Flat Research Range
pH	the negative logarithm of the effective hydrogen ion concentration in gram equivalents per liter, used in expressing both acidity and alkalinity
PM_n	particulate matter with an aerodynamic diameter less than or equal to n micrometers
psi	pounds per square inch

LIST OF ABBREVIATIONS AND ACRONYMS (*Continued*)

QE	quadrant elevation or launch angle
RCRA	Resource Conservation and Recovery Act
RNA	Research Natural Area
ROI	Region of Influence
RS	Radioactive source
RSO	Range Safety Officer
S	sulfur
S-T	stratosphere - troposphere
SEC, sec	second(s)
SEIS	Supplemental Environmental Impact Statement
SHPO	State Historic Preservation Office
SO	stratospheric ozone
Sr	strontium
SRP	Sounding Rockets Program
STS	Space Transportation System (Space Shuttle)
T	threatened
TLV	threshold limit values
TSCA	Toxic Substances Control Act
UAF	University of Alaska Fairbanks
U.S.	United States
U.S.C.	*United States Code*
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VA	Virginia
VRM	Visual Resource Management
WFF	Wallops Flight Facility
WI	Wallops Island, Virginia
WSMR	White Sands Missile Range

COMMON METRIC/BRITISH SYSTEM EQUIVALENTS

Length

1 centimeter (cm) = 0.3937 inch	1 inch = 2.54 cm
1 centimeter = 0.0328 foot (ft)	1 foot = 30.48 cm
1 meter (m) = 3.2808 feet	1 ft = 0.3048 m
1 meter = 0.0006 mile (mi)	1 mi = 1609.3440 m
1 kilometer (km) = 0.6214 mile	1 mi = 1.6093 km
1 kilometer = 0.53996 nautical mile (nmi)	1 nmi = 1.8520 km
	1 mi = 0.87 nmi
	1 nmi = 1.15 mi

Area

1 square centimeter (cm^2) = 0.1550 square inch (in^2)	1 in^2 = 6.4516 cm^2
1 square meter (m^2) = 10.7639 square feet (ft^2)	1 ft^2 = 0.09290 m^2
1 square kilometer (km^2) = 0.3861 square mile (mi^2)	1 mi^2 = 2.5900 km^2
1 hectare (ha) = 2.4710 acres (ac)	1 ac = 0.4047 ha
1 hectare (ha) = 10,000 square meters (m^2)	1 ft^2 = 0.000022957 ac

Volume

1 cubic centimeter (cm^3) = 0.0610 cubic inch (in^3)	1 in^3 = 16.3871 cm^3
1 cubic meter (m^3) = 35.3147 cubic feet (ft^3)	1 ft^3 = 0.0283 m^3
1 cubic meter (m^3) = 1.308 cubic yards (yd^3)	1 yd^3 = 0.76455 m^3
1 cubic meter (m^3) = 0.000811 acre-ft	1233 m^3 = 1 acre-ft
1 liter (l) = 1.0567 quarts (qt)	1 qt = 0.9463264 l
1 liter = 0.2642 gallon (gal)	1 gal = 3.7845 l
1 kiloliter (kl) = 264.2 gal	1 gal = 0.0038 kl

Mass/Weight

1 gram (g) = 0.0353 ounce (oz)	1 oz = 28.3495 g
1 kilogram (kg) = 2.2046 pounds (lb)	1 lb = 0.4536 kg
1 metric ton (mt) = 1.1023 tons	1 ton = 0.9072 metric ton

Energy

1 joule = 0.0009 British thermal unit (BTU)	1 BTU = 1054.18 joule
1 joule = 0.2392 gram-calorie (g-cal)	1 g-cal = 4.1819 joule

Pressure

1 newton/square meter (N/m^2) = 0.0208 pound/square foot (psf)	1 psf = 48 N/m^2

Force

1 newton (N) = 0.2248 pound-force (lbf)	1 lbf = 4.4478 N

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CHAPTER 1

INTRODUCTION AND PURPOSE AND NEED FOR THE ACTION

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1. INTRODUCTION AND PURPOSE AND NEED FOR THE ACTION

Chapter 1 of this environmental impact statement (EIS) provides an overview of the activities of the National Aeronautics and Space Administration (NASA) Sounding Rockets Program (SRP) at Poker Flat Research Range (PFRR) and a brief history of the events leading to the development of this document. Chapter 1 also includes the purpose and need for agency action, the scope of the EIS and decisions to be made, the relationship of this EIS to other National Environmental Policy Act (NEPA) documentation, and a summary of the scoping process used to obtain public input on the issues addressed in this EIS.

The National Aeronautics and Space Administration (NASA) has prepared this *Draft Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* pursuant to the National Environmental Policy Act (NEPA), as amended **(42 U.S.C. 4321 *et seq.*)**; the Council on Environmental Quality's NEPA implementing regulations **(40 CFR 1500–1508)**; and NASA's NEPA policy and procedures **(14 CFR 1216.3)** to analyze the environmental impacts of its continued use of the Poker Flat Research Range (PFRR). PFRR, located outside of Fairbanks, Alaska, is owned and managed by the University of Alaska Fairbanks (UAF). The U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Land Management (BLM), and UAF have served as cooperating agencies because they possess regulatory authority and specialized expertise regarding the proposed action analyzed in this *PFRR EIS*.

1.1 BACKGROUND

UAF is seeking authorizations from USFWS and BLM to allow for continued impact on and recovery on their lands of sounding rockets launched from PFRR as a part of the NASA Sounding Rocket Program (SRP). These authorizations are required because both agencies administer lands downrange from PFRR: USFWS administers the Arctic and Yukon Flats National Wildlife Refuges (NWRs), and BLM administers the White Mountains National Recreation Area (NRA) and Steese National Conservation Area. As such, NASA has prepared this *PFRR EIS* to fulfill the two Federal agencies' NEPA obligations as well as its own.

The purpose of this *PFRR EIS* is to evaluate the potential environmental impacts associated with the proposed action and reasonable alternatives, including a No Action Alternative.

1.1.1 NASA Sounding Rockets Program Background

The NASA SRP, based at the Goddard Space Flight Center's Wallops Flight Facility (WFF), supports NASA's strategic vision and goals for understanding the phenomena affecting the past, present, and future of Earth and the solar system and NASA's educational mission. The suborbital missions enabled by NASA SRP provide researchers with opportunities to build, test, and fly new instrument concepts while simultaneously conducting world class scientific research. With its hands-on approach to mission formulation and execution, NASA SRP also helps ensure that the next generation of space scientists receives the training and experience necessary to move on to NASA's larger, more complex missions.

1.1.2 NASA Sounding Rockets Program Launch Sites

Sounding rockets can be launched from permanently established ranges or from temporary launch sites using NASA's mobile range assets. Permanent ranges include WFF in Wallops Island, Virginia; PFRR near Fairbanks, Alaska; White Sands Missile Range (WSMR) in White Sands, New Mexico; Kwajalein Island in the Marshall Islands Republic; Esrange Space Center near Kiruna, Sweden; and the Norwegian Sounding Rocket Ranges in Andøya, Norway and Ny-Alesund, Svalbard (Norway). In the past, there have been temporary launch sites in Australia, Brazil, Greenland, and Puerto Rico. The majority of sounding rocket launches occur at WFF, PFRR, and WSMR.

Where NASA SRP conducts its work is highly dependent on the scientific goals of each mission. For example, if equatorial phenomena must be observed, a site such as Brazil is used. For middle latitudes, WFF or WSMR is selected. If the aurora borealis must be observed, a site at very high latitudes is required, such as at PFRR.

1.1.3 PFRR Background

PFRR, located northeast of the unincorporated village of Chatanika, Alaska, consists of approximately 2,100 hectares (5,200 acres) of land that house rocket and payload support facilities, launch pads, and tracking infrastructure. Since the late 1960s, NASA, other government agencies, and educational institutions have supported suborbital rocket launches from PFRR. PFRR is owned and managed by the Geophysical Institute of UAF; however, NASA SRP has exclusively funded and managed the support contract with PFRR for more than 25 years.

The location of PFRR is strategic for launching sounding rockets for scientific research in auroral space physics and earth science. PFRR is the only high-latitude, auroral-zone rocket launching facility in the United States where a sounding rocket can readily study the aurora borealis and the Sun–Earth connection (discussed in more detail below). The information collected further assists the Nation's scientists in understanding the interactions between the Sun and Earth, as well as the origin and evolution of the solar system. Technology development and validation enabled by NASA SRP at PFRR is critical in furthering the development of earth and space science instruments at a fraction of the size and cost that would result from using other launch methods. PFRR also supports educational outreach programs in which students and scientists from various universities conduct aeronautics and space research.

1.1.4 Existing NASA SRP NEPA Documents and Context

In 2000, NASA published the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* **(NASA 2000a)**. The 2000 *SRP SEIS* considered NASA SRP operations at a programmatic level and expanded upon the original *Final Environmental Impact Statement for Sounding Rocket Program (SRP EIS)* prepared in 1973 to include multiple launch sites, new launch vehicles, and updated environmental conditions. In its Record of Decision (ROD) for the 2000 *SRP SEIS*, NASA decided to continue NASA SRP operations at its current level of effort at all launch sites, including PFRR. Since then, NASA has launched approximately four sounding rockets annually from PFRR primarily during the winter months (defined as October through April for the purposes of analysis).

Since issuing its ROD in June 2000, NASA has performed an annual NEPA review of all of its proposed sounding rockets missions, including those at PFRR. In each instance, NASA has found that all proposed missions have been within the scope of those analyzed in the 2000 *SRP SEIS*.

NASA most recently reviewed its 2000 *SRP SEIS* and determined that the overall environmental analysis in the document remains sufficient to support NASA's broad programmatic decision to continue NASA SRP; however, potential changes in both PFRR operations and the environmental context of the launch corridor north of PFRR warrant preparation of additional PFRR-specific environmental analysis to better inform NASA's decisionmaking regarding PFRR. For example, PFRR is now considering a more rigorous rocket spent stage and payload recovery process. Additionally, a large portion of downrange lands are undergoing Wilderness review, which could ultimately affect how rocket launches and payload recoveries are handled.

Accordingly, NASA began preparing an environmental assessment (EA) to determine if those changes potentially presented a significant impact necessitating an EIS. During the scoping process for the EA in the fall of 2010, NASA solicited input from over 75 potentially interested agencies and organizations. A number of conservation organizations expressed concern regarding NASA's continued operations at PFRR and requested that a more detailed assessment be performed. Considering this input, NASA decided that an EIS would be the most appropriate level of NEPA documentation for the proposal. This PFRR EIS tiers from the programmatic 2000 *SRP SEIS* and provides a focused analysis of NASA SRP operations at PFRR.

1.1.5 Science Conducted by NASA SRP at PFRR

To best understand the types of science enabled by the PFRR, one must first have a basic comprehension of the phenomena that are typically the subject of the research. The following section is intended to provide the reader with an overview of the natural forces that are most often studied and why they are of interest to the Nation's scientists.

NASA SRP facilitates research at PFRR primarily in support of a scientific discipline known as Heliophysics – its name derived from the Greek words *helios* for the Sun and *physika*, the science of the natural world. Heliophysics is the exploration of the Sun, its effects on Earth and the planets of the solar system, and space environmental conditions and their evolution.

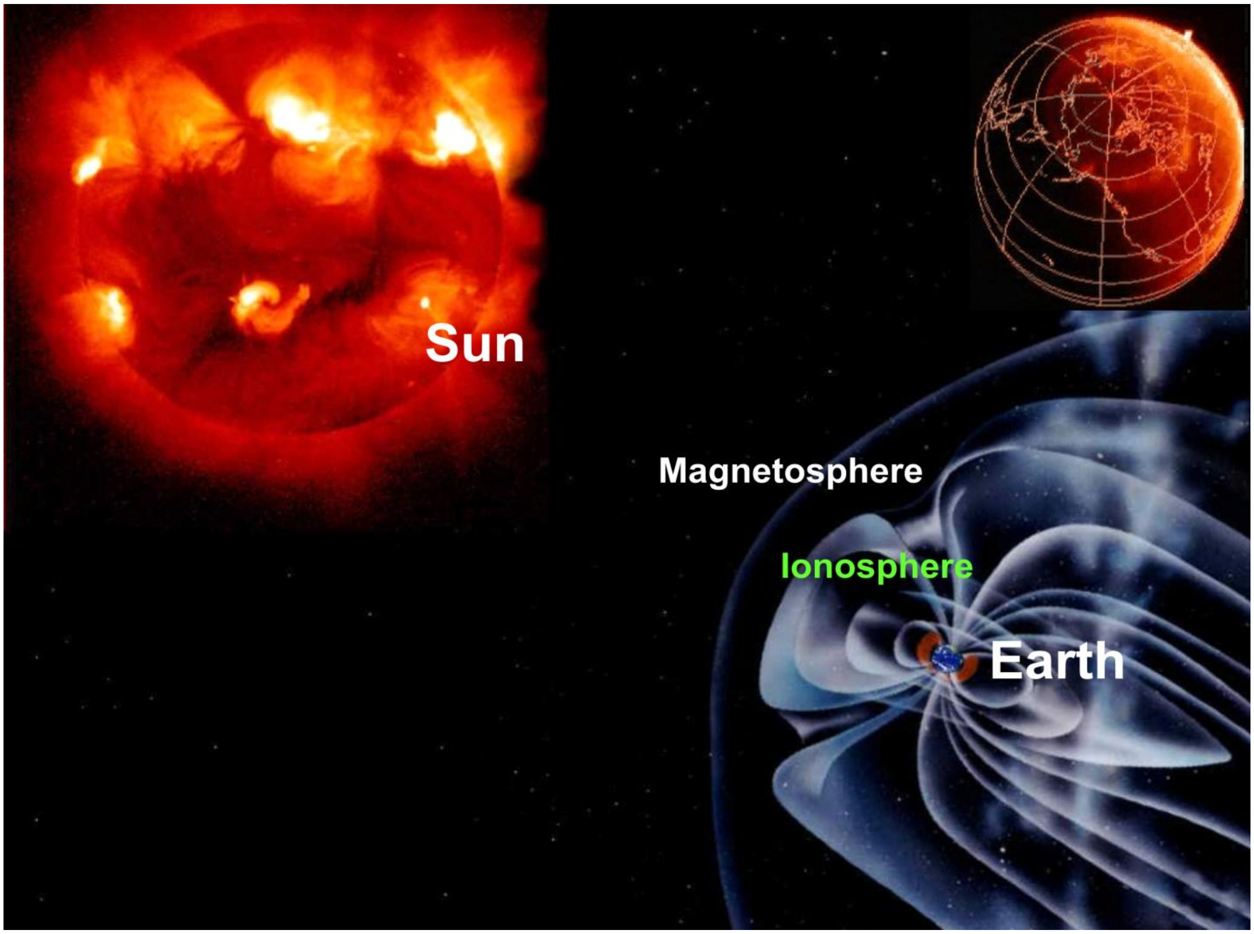
The Earth's upper atmosphere and magnetic field form a coupled system with the Sun and geospace (the space inside the protective cavity of Earth's magnetic field); therefore, a main scientific objective is to understand how the Sun, geospace, and Earth's upper atmosphere are connected in a single system.

A term commonly used in the heliophysical sciences is the "Sun–Earth connection," which refers to the transfer of electromagnetic radiation and high energy particles from the Sun to the Earth. This radiation consists of ultraviolet (UV), extreme UV, X-ray, and gamma rays that would be harmful to life on Earth if it were not protected by its upper atmosphere. The charged particles, referred to as the "solar wind", would also be very harmful if Earth were not protected by its magnetic field, or magnetosphere, which excludes most of these energetic particles. However, the magnetosphere can also trap, store, and energize charged particles, with these upper-atmospheric electric currents forming what are known as auroras. **Figure 1–1** shows a picture of an aurora borealis over PFRR.

Source: GI 2010.

Figure 1–1. Aurora Borealis over Poker Flat Research Range

An aurora (plural: *auroras* or *aurorae*) is a natural light display in the sky particularly in the high latitude (Arctic and Antarctic) regions, caused by the collision of energetic charged particles with atoms in the upper atmosphere, which glow as they release the energy. The Earth's magnetic field looks like that of a dipole magnet where the field lines are coming out and going into the Earth near the poles. The energized particles travel along the Earth's magnetic field lines and are thus guided to the high latitude atmosphere. Most aurorae occur at an altitude of 90–130 kilometers (56–81 miles) above Earth in a band known as the auroral zone which is typically 3 to 6 degrees in latitudinal extent and at all local times or longitudes. The auroral zone is typically 10 to 20 degrees from the magnetic pole defined by the axis of the Earth's magnetic dipole. **Figure 1–2** shows the Sun-Earth connection with magnetic field lines coming into the magnetic poles. To see aurora, the sky must be dark and clear.



Source: UNH 2006.

Figure 1–2. Sun with Earth Protective Magnetic Field

As the presence of aurorae in the sky indicates disturbance in the upper atmosphere, their formation can also be associated with the disruption of a host of technologies upon which modern society heavily depends. Strong electrical currents driven in the Earth's surface during auroral events can disrupt and damage modern electric power grids and may contribute to the corrosion of oil and gas pipelines. Changes in the ionosphere during geomagnetic storms interfere with high-frequency radio communications and global positioning system navigation. During polar cap absorption events caused by solar protons, radio communications can be severely compromised for commercial airliners on transpolar crossing routes. Exposure of spacecraft to energetic particles during solar energetic particle events and radiation belt enhancements can cause temporary operational anomalies, damage critical electronics, degrade solar arrays, and blind optical systems such as imagers and star trackers used on commercial and government satellites.

Therefore, to better understand and predict "space weather" and the effect of solar activity on the Earth, government and university scientists regularly conduct experiments using a variety of tools, including orbiting satellites, ground-based observation stations, and in-situ probes such as sounding rockets. The aurora contains a large range of unexplained, critical phenomena that can only be explored with in situ probes on sounding rockets, which gather vertical profiles of measured parameters, which are essential for the study of the upper atmosphere and ionosphere. In some cases, Earth-orbiting satellites cannot gather adequate measurements as the satellites are traveling too fast or are too high.

Accordingly, to fill these scientific requirements, researchers develop experiments that fly aboard sounding rockets at high-latitude launch sites such as Poker Flat. A majority of the science enabled by PFRR can be considered fundamental science (or pure science), the goal of which is to understand the most basic forces of a phenomenon, relationships between them, and laws governing them. The knowledge gained by the research at PFRR can then be applied practically by scientists and engineers in related disciplines, such as in the design of a more resilient communications system or a more corrosion-resistant pipeline.

The data collected at PFRR also benefit climate change research, though mainly indirectly. For example, data collected by sounding rockets (*e.g.,* ionospheric density, neutral density and temperature, electric fields) in upper atmospheric regions can be utilized to develop and calibrate atmospheric models to assess change (*e.g.,* **Qian *et al.* 2008**). Of particular note are those "whole atmosphere" models that can consistently simulate the dynamic processes of the Sun–Earth system **(Liu *et al.* 2010)**. These models require data to perform realistic predictions. The only way to gather the necessary measurements in the upper atmosphere (altitudes between 30 and 160 kilometers [20 and 100 miles]) is with probes on sounding rockets.

In addition to the majority of PFRR missions, which study the aurora and its associated physical processes, some missions' objectives are directly related to weather and climate change. For example, a February 2011 mission investigated a technique to measure the nighttime distribution of nitric oxide, a compound produced by aurora and thought to descend to lower altitudes during long polar nights, where it is a destroyer of ozone. If this process occurs, it is likely to impact the wind patterns of the stratosphere, which would then affect the Earth's climate.

Other sounding rocket-enabled studies have measured movement of upper atmospheric winds during auroral events in the ionosphere. The information collected further assists the Nation's scientists in understanding the interactions between the Sun and Earth, as well as the origin and evolution of the solar system. **Table 1–1** provides some detail for sounding rockets science missions.

Table 1–1. Science Provided by Selected PFRR Sounding Rocket Missions

Science	Mission	Date	Scientific Purpose
Space Weather	30.058UE and 30.059UE Lynch	January – February 2005	To make multiple measurements of the structure of mesospheric dust layers under varying conditions using identical instrumentation. Data obtained from these missions will be utilized to study the effects of mesospheric meteoric dust layers on mesospheric and atmospheric processes such as sudden atom layers, noctilucent clouds, and polar mesospheric summer echoes.
Magnetospheric, Ionospheric, Thermospheric, and Mesospheric Physics Auroral Science	JOULE II: Mulitple-Scale Study of High-Latitude Joule Heating During a Substorm Event ROPA: Rocket Observations of Pulsating Aurora HEX 2: Investigations of Mesoscale Drivers for Vertical and Horizontal Winds in the High-Latitude Lower Thermosphere CHARM: Correlations of High-Frequencies and Auroral Roar Measurements	January – February 2007	2007 campaign of 10 launches to investigate disturbances in the ionosphere near the magnetic field. Four separate scientific missions were conducted, with each mission consisting of ground-based observations of the ionosphere followed by a series of sounding rocket launches once specific phenomena were observed. A series of 10 sounding rockets were launched carrying a variety of payloads into the ionosphere to make in-situ measurements of the observed phenomena.
Ionospheric Physics, Student Mentoring	30.073UO Thorsen	January 10, 2009	To measure plasma and geomagnetic structure of the high latitude D-region.
Auroral Science	21.139 and 36.242UE Bounds	January 29, 2009	To study electric fields and current structure within an aurora.

Table 1–1. Science Provided by Selected PFRR Sounding Rocket Missions (*continued*)

Science	Mission	Date	Scientific Purpose
Earth's ionosphere thermosphere system and the Sun–Earth interface	41.077, 41.078, 41.079UE Lehmacher	February 18, 2009	To determine the uppermost levels of neutral air turbulence in the Earth's atmosphere.
Auroral Science	40.023UE Lynch	March 20, 2009	To investigate motions and structure of electron precipitation in a pre-midnight poleward edge discrete aurora.
Atmospheric Science and Climate	Polar NOx 36.256UE Bailey	February 4, 2011	To investigate a technique where the attenuation of star light was used to measure the night time altitude distribution of nitric oxide, a compound produced by aurora and thought to descend to lower altitudes during long polar nights, where it is a destroyer of ozone. If this process occurs, it is likely to impact the wind patterns of the stratosphere which would then affect the Earth's climate.

1.1.6 Cooperating Agency Actions

This *PFRR EIS* serves as a decisionmaking tool not only for NASA but also for its two Federal cooperating agencies, USFWS and BLM. Directly north of PFRR is its downrange launch corridor, over which rockets are launched and within which spent stages and payloads impact the ground. Within the launch corridor are landmasses owned or managed by several Federal, state, and Alaska Native organizations, including USFWS, BLM, Alaska Department of Natural Resources, Doyon Limited (an Alaska Native regional corporation created by the Alaska Native Claims Settlement Act), and the Native Village of Venetie Tribal Government (see **Figure 1–3**).

1.1.6.1 *BLM*

BLM manages and administers the use of Federal public lands and resources on behalf of the Department of the Interior in accordance with the Federal Land Policy and Management Act of 1976, as amended (FLPMA) **(43 U.S.C. 1701 *et seq.*)**. The agency's Eastern Interior Field Office in Alaska manages approximately 8 million acres of public lands in east-central Alaska, including the north and south units of the Steese National Conservation Area and the White Mountains NRA.

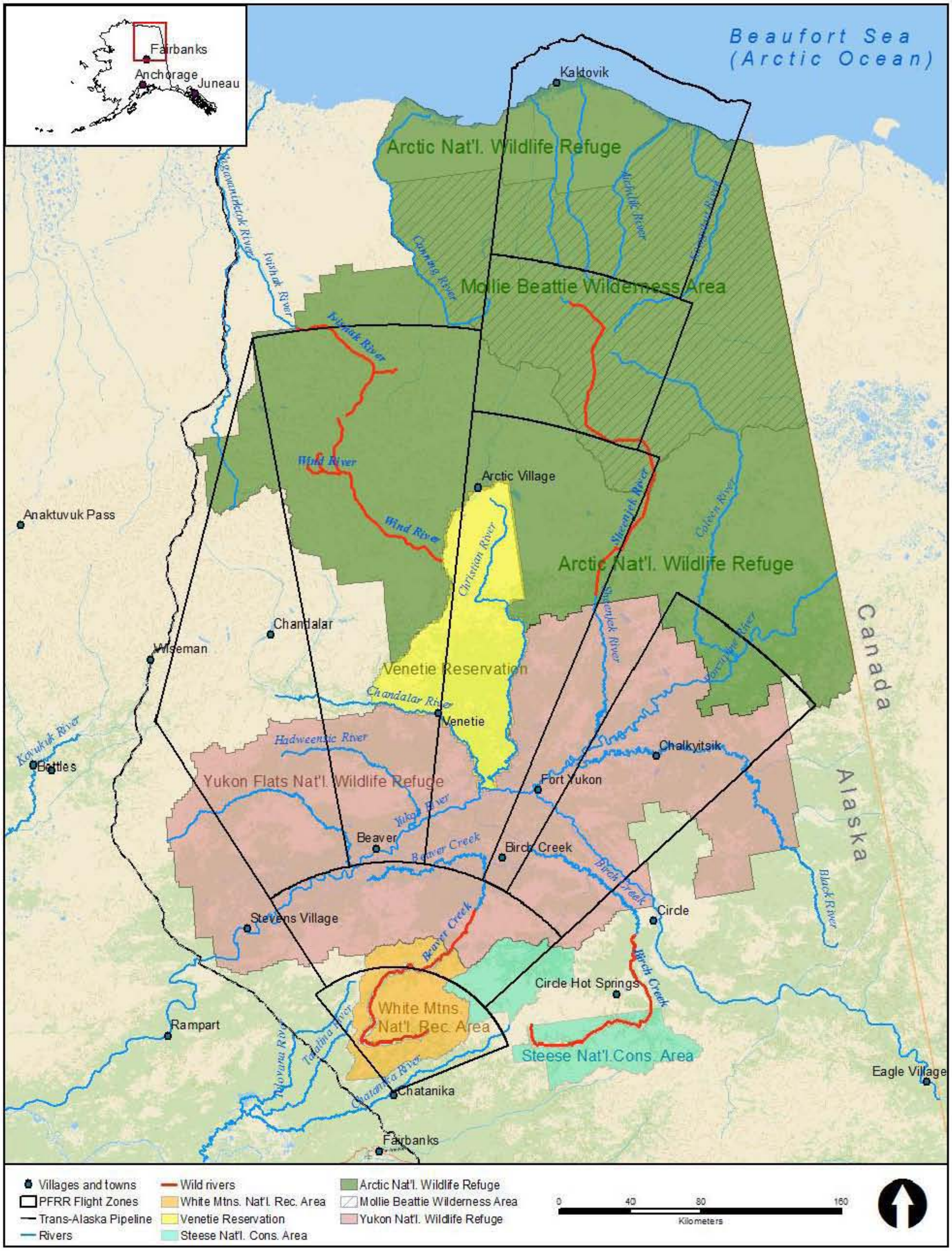


Figure 1–3. Poker Flat Research Range Launch Corridors

1.1.6.2 *USFWS*

The USFWS administers NWRs on behalf of the Department of the Interior in accordance with the National Wildlife Refuge System Administration Act of 1966, as amended (NWRSAA) **(16 U.S.C. 668dd-668ee)**. These lands are administered for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats. The Alaska Region (Region 7) of USFWS administers 16 NWRs within the state of Alaska. The primary purpose of Arctic and Yukon Flats NWRs is to conserve fish and wildlife populations and their habitats in their natural diversity. The USFWS is authorized to permit by regulations the use of any area within the NWR system provided "such uses are compatible with the major purposes for which such areas were established."

1.1.6.3 *Decisionmaking Context*

In the past, BLM and USFWS have issued UAF annual or multi-year special-use permits and agreements for impact of sounding rockets and recovery operations on these lands. USFWS and BLM are currently considering if and how future permits for sounding rocket landing and recovery would be issued for the properties under their management. Additionally, both agencies are currently preparing long-term management plans for their respective landholdings. BLM is currently updating its Eastern Interior Resource Management Plan; Arctic NWR is updating its Comprehensive Conservation Plan; and the process for updating the Yukon Flats NWR Comprehensive Conservation Plan is expected to begin within the next several years. The results of these planning processes will play a significant role in how future launches from PFRR would occur. As such, this *PFRR EIS* considers the effects of each agency's respective permitting actions within the context of their long-term management objectives.

1.2 PURPOSE

1.2.1 NASA (Lead Agency) Purpose Statement

NASA's purpose for action is to enable the continued safe and cost-effective sounding rocket based scientific investigations at PFRR. NASA launches sounding rockets at PFRR to support advancement of scientific knowledge of the Sun–Earth connection, the upper atmosphere, and global climate change. NASA intends to maintain a high-latitude launch site in the United States (U.S.) to support this research, as it is critical to the understanding of the aforementioned science. To meet this purpose, NASA needs UAF to secure authorizations on its behalf from USFWS and BLM to continue use of PFRR.

1.2.2 BLM (Cooperating Agency) Purpose Statement

BLM has received a permit application **(USDOI 2010)** from PFRR. The purpose of the BLM's action is to respond to the request for use of public lands under the authority granted to the Department of the Interior by the FLPMA. If approved, the permit would authorize rocket impacts and recovery of NASA SRP spent rocket stages and payloads from BLM-administered lands.

1.2.3 USFWS (Cooperating Agency) Purpose Statement

Similar to BLM, USFWS has received a permit application from PFRR. The purpose of the USFWS's action is to respond to the request for use of public lands under its authorities granted by the NWRSAA. If approved, the permit would authorize rocket impacts and recovery of NASA SRP spent rocket stages and payloads from Arctic and Yukon Flats NWRs.

1.3 NEED

1.3.1 NASA Need Statement

The proposed action is needed to ensure that NASA and the global science community have a U.S. based launch capability to conduct experiments to aid in the understanding of the phenomena affecting the past, present, and future of the Earth and the Sun–Earth connection. Sounding rockets permit the only means to study the lower atmosphere (40–80 kilometers [25–50 miles]) and the middle ionosphere (80–150 kilometers [50–93 miles]) with direct measurements, and the only means to explore the upper ionosphere (150–1,500 kilometers [93–930 miles]) with vertical trajectories on slowly moving platforms. These are essential regions of the Earth's environment and must be measured to understand how the Earth and space interact and phenomena such as the aurora. The northern location of PFRR is strategic for launching NASA sounding rockets for scientific research in auroral space physics and earth science. PFRR is the only high-latitude, auroral-zone rocket launching facility in the United States where a sounding rocket can readily study the aurora borealis and the Sun–Earth connection as described in Section 1.1.5.

PFRR offers a number of operational and scientific features that enhance its usefulness to the NASA SRP scientific mission, including the following:

- The launch pads are directly within the Earth's auroral zone, a key region where energy is transferred between the atmosphere and the magnetosphere and solar wind. The range is also well located for studies of other arctic atmospheric phenomena, such as polar mesospheric summer echoes and noctilucent clouds.
- The available flight corridor enables high-altitude, long-range rockets to be launched safely toward the north.
- The range permits up to five nearly simultaneously launches, including ones along different azimuths (for low-altitude trajectories).
- The range includes an unprecedented array of established, ground-based research instruments (*e.g.,* magnetometers, all-sky cameras, and lidars) that are part of the infrastructure and are broadcast to the science operations center to permit launches into optimum scientific conditions. The data from decades of observations from these ground-based instruments constitute an essential knowledge base that provides the environmental context for interpreting rocket measurements.
- The range includes a world-class, state-of-the-art, National Science Foundation incoherent scatter radar that allows correlative measurements to be obtained with the rocket launches, therefore enhancing the overall scientific return. This radar enables

observations of the upper atmosphere through its advanced capabilities, notably its ability to measure variations in the ionosphere continuously over extended time scales and with high resolution **(NSF 2005)**.

- The range allows sounding rockets to be launched over accessible sites on land, permitting observers to be located downrange with optical and other instruments and including autonomous instrument observations from downrange stations (*e.g.,* Fort Yukon and Kaktovik) over which the sounding rockets fly. Only optical observations nearly along the magnetic field direction allow assessment of the spatial distribution of the aurora. This is especially important when small-scale auroral structures are critical to the science. If the optical observations are made at too low of elevation angle (*i.e.,* away from the magnetic field direction), auroral structures cannot be resolved and will blend together.
- Directly north (downrange) of the launch site are vast areas of open, very sparsely populated lands. Having the ability to launch sounding rockets safely over such a vast area with very low population density is critical to ensuring public safety.
- The range enables the recovery of rocket payloads.
- The range offers the unique advantages of being located near a permanent staff of university space physics scientists (at UAF) dedicated to studying the aurora, and of being located at a site at the southern edge of the zone where most auroras occur.
- The range has good road access. Its proximity to Fairbanks means NASA scientists and others are able to travel to the project site on regular commercial flights. Fairbanks also provides good accommodation for campaign personnel and extensive local businesses from which goods and services can be obtained as needed to support launch operations.
- Because of its affiliation with UAF, there are many opportunities for student groups to experience a sounding rocket launch or to see a mission in preparation, *e.g.*, as a class excursion. Furthermore, the lack of restrictions on foreign national access to the range enhances the opportunities for missions involving international collaboration.

Technology development and validation enabled by NASA SRP at PFRR are critical in furthering the development of earth and space science instruments at a fraction of the size and cost that would result from using other launch methods.

1.3.2 BLM and USFWS Need Statement

The two Federal cooperating agencies' proposed actions are needed because the Secretary of the Interior delegated the authorities granted in the FLPMA and NWRSAA to the BLM and USFWS, respectively, to authorize the use of public lands in accordance with their guiding polices for management.

1.4 FEDERAL SCOPING ACTIVITIES TO DATE

NASA has pursued multiple avenues to notify the public of opportunities for involvement and methods to comment on NASA's intent to prepare an EIS, as outlined below.

1.4.1 Pre-EIS Scoping

NASA began the preparation of an EA in 2010 to determine if those changes potentially presented a significant impact necessitating an EIS. During the scoping process for the EA in the fall of 2010, NASA solicited input from over 75 potentially interested agencies and organizations. The scoping comments received as a part of the 2010 EA effort led to NASA's decision to prepare this *PFRR EIS* and were therefore considered for establishing the scope of the document.

A summary of the comments received during the NASA 2010 EA scoping process, along with where the comment is addressed in this EIS, as applicable, is presented by topic area in **Table 1–2**.

Table 1–2. NASA 2010 Environmental Assessment Scoping Comments Summary

Comment	Addressed in EIS?	If yes, location; if no, rationale
Level of Environmental Analysis		
The NEPA documentation should be changed from an EA to an EIS.	Yes	1.4.1
Concerns that there was a gap in a compatibility finding to the 2000 *SRP SEIS* to cover 2000–2005.	No	Outside the scope of this EIS.
The environmental analysis should include: ○ Designated trails occurring on Federal public lands on the maps, notably the White Mountains National Recreation Area.	Yes	4.8.2.1
○ All landings, including rockets, missiles, balloons, and any other vehicles or objects that have been launched and landed since 1969.	Yes	4.15.12
○ The percentage of the fallout materials that return to Earth that has been recovered.	Yes	2.1.7.2
○ Technical information regarding why some stages can be tracked and recovered and others cannot, including if the limitation is a cost limitation.	Yes	2.4.5 and 2.4.6
○ Methods for recovering all stages of the types of rockets that land on public lands.	Yes	2.1.7.2
○ The types and utility of the experiments in SRP.	Yes	1.1.5
○ The duration of the authorizations sought from USFWS and other Federal land managers, as well as any renewal procedures or procedures to make changes to the authorizations.	Yes	1.1.6.3
○ Definition of a mission (*i.e.*, one research vessel/rocket being launched during a "mission" or several).	Yes	2.1.1
○ A layperson's version of NASA's methods for estimating where debris will land and if winds and climate parameters in the layers of the atmosphere the rockets are passing through on launch and reentry are taken into consideration; request for how values are acquired/derived.	Yes	2.1.6.1 and 2.1.6.2

Table 1–2. NASA 2010 Environmental Assessment Scoping Comments Summary (*continued*)

Comment	Addressed in EIS?	If yes, location; if no, rationale
Alternatives		
Request for analysis of alternatives to PFRR research conducted at altitudes of 50 to 90 kilometers (31 to 56 miles).	Yes	2.4.4
Request for analysis of alternative launch locations.	Yes	2.4.2, 2.4.3, and Appendix B
Request for analysis of other areas that could be used for this program that are alternatives to the current location.	Yes	2.4.2, 2.4.3, 2.4.8, and Appendix B
Support for EA Alternative 3, Complete Recovery, to reduce the amount of manmade debris strewn about the state, subject to the affected property owner's concurrence.	Yes	2.3.5
Cooperating Agencies		
NASA should involve USFWS and BLM as principal agencies, rather than cooperating agencies.	No	NASA is the Federal action proponent and, therefore, the lead agency.
NASA should involve USFWS in this EIS with greater examination of compatibility between wilderness areas and launch program.	Yes	4.8
Concern about impacts on the Arctic Refuge Comprehensive Conservation Plan.	Yes	4.15.1.6 and 4.15.5.4
Public Awareness		
Concerns that public, community, and native villages are unaware of the EA.	Yes	1.4
Suggestion to include public meetings at places such as the Chatanika Lodge on the Steese and Hilltop Café on the Elliott, given that impacts occur within the borough and near the settled areas of the Steese and Elliott Highways.	No	NASA mailed meeting notices to Chatanika Lodge.
Wilderness Areas and Minimal Management Areas		
Concerns about impacts on lands undergoing Wilderness Review and the non-wilderness character of rocket launches and debris.	Yes	4.15.5.4
Comment that the Arctic National Wildlife Refuge provides unparalleled wilderness experience and is of extraordinarily high cultural, subsistence, recreation, wilderness, and wildlife value.	Yes	3.8.2.3
Comment that sending rocket debris into the Arctic Refuge is a gross violation of the wild character of the Arctic Refuge.	No	Does not request analysis of a specific environmental resource area or alternative.

Table 1–2. NASA 2010 Environmental Assessment Scoping Comments Summary (*continued*)

Comment	Addressed in EIS?	If yes, location; if no, rationale
Wilderness Areas and Minimal Management Areas (*continued*)		
Comment to treat minimal management areas as though they are fully designated wilderness area.	No	This decision is outside of the scope of this EIS.
The environmental analysis should identify potential impacts on wilderness/remote experience users.	Yes	4.8
Concerns about impacts on designated wilderness and wilderness study areas. The probability should be stated and represented by showing the different levels of uncertainty (one- to X-sigma) around each predicted landing for each stage of each rocket. The boundaries of designated wilderness and wilderness study areas should be included on the maps. Stages recovered from designated wilderness in the past should be identified, including stage, predicted landing coordinates, actual landing coordinates, and means of recovery.	Yes	4.8 and 4.15.5
Biology		
Concerns about wildlife mortality and habitat disturbance from direct strikes and shrapnel.	Yes	4.7.4 and 4.7.6
Soils		
Concerns about soil contamination from hazardous materials and ground disturbance from direct strikes and shrapnel.	Yes	4.4 and 4.12
Water		
Concerns about water contamination from hazardous materials and ground disturbance from direct strikes and shrapnel.	Yes	4.3 and 4.12
Concern regarding the batteries/radioactive material/debris impacting the waterways.	Yes	4.3 and 4.12
The location of the proposed project is not within the coastal zone boundaries of the Alaska Coastal Management Program. Therefore, a state review for consistency is not required.	Yes	4.3.1
There may be waters of the United States under U.S. Army Corps of Engineers regulatory jurisdiction impacted by the PFRR activities.	Yes	3.3.1
Concerns about large debris landing in the riverways, and potentially impeding traffic or becoming a hazard to navigation. (The U.S. Coast Guard will be conducting outreach and research into the types and volume of vessel traffic the rivers located in the various impact zones [there are a few barges that are known to operate out of the Nenana and other immediate areas, but the extent of their operations on the identified river impact zones in unknown]).	Yes	4.3.2.1
Concerns from the Coast Guard that if a rocket impact zone is within a waterway, the Coast Guard has a duty to create a safety or security zone to provide public awareness.	Yes	2.1.6.1

Table 1–2.NASA 2010 Environmental Assessment Scoping Comments Summary (*continued*)

Comment	Addressed in EIS?	If yes, location; if no, rationale
Hazardous/Solid Waste		
Concerns about hazardous material impacts on persons or wildlife.	Yes	4.7.4, 4.7.6, 4.12, and 4.13
Concerns about recovery of existing debris.	Yes	2.1.7.2 and 4.15.9
Request to know types of hazardous substances involved in the program and impacts on Federal lands; the risk of releasing these hazardous materials to the environment; whether or not hazardous materials have been released, and if so, what quantities in each particular site; and what the methods and success rate for cleanup have been and/or will be in the future.	Yes	4.12 and 4.13
Recreation and Subsistence Hunting		
Concerns about impact on recreation, specifically the Arctic National Wildlife Refuge, including its designated wilderness lands and designated wild river corridors, and Yukon Flats National Wildlife Refuge, including its wild river corridor and agency-recommended wilderness area, as well as other Federal lands in the area in question, such as Beaver Creek National Wild and Scenic River and White Mountains National Recreation Area.	Yes	4.3 and 4.8
The environmental analysis should include designated trails occurring on Federal public lands on maps (i.e., White Mountains National Recreation Area).	Yes	4.8.2.1
Concerns about impacts on subsistence value of all Federal lands involved.	Yes	4.7.5, 4.10, and Appendix D
Socioeconomics		
The environmental analysis should include a cost/benefit analysis addressing: o Annual program budget	Yes	4.14.1
o Rocket recovery budget under each alternative	Yes	2.3.4
o Costs of alternatives	Yes	4.14.1
o Whether more cost-effective alternatives exist to obtain the results/information provided by the NASA SRP	Yes	2.4.4
Miscellaneous Concerns		
Concerns about other agencies being able to obtain launch permits at PFRR.	No	Outside the scope of this EIS.
Concerns about violations of Alaska National Interest Lands Conservation Act, National Wildlife Refuge System Improvement Act, Federal Land Policy and Management Act, Wilderness Act, and NEPA.	Yes	4.8

Key: BLM=U.S. Bureau of Land Management; EA=environmental assessment; EIS=environmental impact statement; NASA=National Aeronautics and Space Administration; NEPA=National Environmental Policy Act; PFRR=Poker Flat Research Range; SRP=Sounding Rockets Program; *SRP SEIS=Final Supplemental Environmental Impact Statement for Sounding Rocket Program*; USFWS=U.S. Fish and Wildlife Service.

1.4.2 EIS Scoping

Notice of Intent

The initiation of this EIS scoping process began with the publication of a Notice of Intent (NOI) in the *Federal Register* on April 13, 2011, announcing NASA's intent to prepare an EIS to analyze the environmental and socioeconomic impacts associated with continuing sounding rocket operations at PFRR. The publication of the NOI officially marked the beginning of the scoping period, during which time NASA accepted public comments on the proposed action. The NOI also provided background information; the proposed alternatives, including a No Action Alternative; a request for comments; a point-of-contact; and an announcement of the public scoping meeting times and locations. A copy of the NOI is included in Appendix A.

Correspondence

Pursuant to American Indian/Alaska Native Policy and Implementation Guidance, NASA mailed and faxed official government-to-government consultation letters inviting Alaska Native leadership and members to participate in the scoping process for the preparation of this EIS. The letter provided information similar to that contained in the NOI. A copy of this letter and the enclosures describing the proposed action are included in Appendix A. Alaska Native consultation responses to the letter are contained in Appendix A.

On April 14, 2011, NASA distributed a scoping letter to government representatives, the general public, and agencies having jurisdiction over resources within the PFRR region of influence. The purpose of this letter was to share details regarding the proposed actions and alternatives, advertise the scoping meetings, and receive feedback from various agencies regarding the potential issues of concern.

Media

NASA distributed newspaper and radio advertisements to announce the NOI and the scoping meetings. In addition, NASA distributed a public scoping press release to newspaper, television, and radio channels covering the locations where public scoping meetings were being held. NASA representatives interacted with media during the scoping period. Media interactions included a radio interview with the Fort Yukon public radio station, KZPA; an interview with the Fairbanks local television station, radio station KTVF; and an interview with UAF Geophysical Institute Science Writer, Ned Rozell.

Meetings

NASA held five scoping meetings from April 28 through May 3, 2011, in Fort Yukon, Fairbanks, and Anchorage, Alaska to gather community-specific issues and concerns on which to focus this EIS analysis. The public scoping meetings provided an opportunity for the public to receive information about the proposed action and alternatives and assist NASA in identifying potential environmental impacts and key issues of concern. At the meetings, NASA provided comment forms; an email address; a recorder who could enter oral comments by attendees either in private or during the comment portion of the meetings; and contact information for standard mail, phone, and fax. Twenty-eight people, including governmental and PFRR representatives, signed in as attending the public scoping meetings.

Identification of Issues

NASA solicited input from approximately 140 potentially interested citizens, tribes, agencies, and organizations. Overall, local citizens, tribes and agencies were mostly concerned about the rocket spent stages landing in the Wilderness Areas, including concerns about physical and chemical impacts, as well as impacts on the wilderness aesthetic values. Commenters also had concerns about the lack of awareness that these rocket launches are ongoing. During the NASA 2010 EA scoping, the public and government agencies raised similar issues, emphasizing concerns about impacts on Wilderness Areas and Wilderness study areas.

A summary of the comments received during the *PFRR EIS* scoping process, along with where the comment is addressed in this EIS, as applicable, is presented by topic area in **Table 1–3**.

In the spring of 2011, in response to the public comments expressed during the EA and EIS scoping meetings, NASA modified the proposed actions and alternatives. These modifications are presented in this *Draft PFRR EIS*.

Table 1–3. *PFRR EIS* Scoping Comments Summary

Comment	Addressed in EIS?	If yes, location; if no, rationale
Level of Environmental Analysis		
This EIS should provide more information about targeted areas in the future.	Yes	Chapter 4 front matter/assumptions and Appendix G
This EIS should show a range diagram with areas to be avoided.	Yes	1.1.6
This EIS should state the probability of a rocket landing and show the different levels of uncertainty around each predicted landing for each stage of each rocket.	Yes	2.1.6.2
This EIS should indicate the success rates for launches.	Yes	3.13.4.2
This EIS should account for all the stages when predicting the number of spent stages.	Yes	4.15.9
This EIS should provide more clarity about the quantity and location of past launch debris.	Yes	4.15.9
This EIS should assess risks of wildlife for launches during non-winter months.	Yes	4.7.8

Table 1–3. *PFRR EIS* Scoping Comments Summary (*continued*)

Comment	Addressed in EIS?	If yes, location; if no, rationale
Alternatives		
NASA needs to establish the ability to control or predict the impact sites.	Yes	2.1.6.2
This EIS should consider timing flights to avoid migratory bird or other terrestrial mammal breeding times.	Yes	2.1.2.4, 4.7.4, and 4.7.8
This EIS should address cumulative impacts.	Yes	4.15
Wilderness Areas and Minimal Management Areas		
This EIS should consider impacts on wilderness quality lands, wild and scenic rivers, and national recreational land values and the impacts on the experience of those using such lands for wilderness or remote experiences.	Yes	4.8
NASA should clean up the messes in the Arctic Refuge.	Yes	2.1.7.2 and 2.3.4
The public has concerns about impacts on Federal lands.	Yes	4.8
Safety		
This EIS needs to consider a spent stage hitting the Trans-Alaska Pipeline.	Yes	4.13.2.2
Hazardous/Solid Waste		
NASA should not be using public lands as dumping grounds.	No	Does not request analysis of a specific environmental resource area or alternative.
Recreation and Subsistence Hunting		
Concerns about impacts on subsistence value of all Federal lands involved.	Yes	4.10 and Appendix D
This EIS should address the impacts on subsistence hunting needs from recovery operations during the summer.	Yes	4.10 and Appendix D
Socioeconomics		
NASA should place a value on recovery of stages.	Yes	2.3.4
This EIS should clearly show what efforts were made to fulfill environmental justice requirements.	Yes	4.13.3
Funding should be set aside to promote scientific and engineering education within the Native Villages that may be affected by launch operations.	No	Outside the scope of this EIS decisionmaking.

Table 1–3. *PFRR EIS* Scoping Comments Summary (*continued*)

Comment	Addressed in EIS?	If yes, location; if no, rationale
Recovery of Rocket Hardware		
This EIS should describe methods for recovering all stages of the types of rockets that are landing on public lands.	Yes	2.1.7.2 and 2.3.4
This EIS should include a discussion of technologies that could improve location and recovery.	Yes	2.3.4
NASA should describe the Recovery Award Program.	Yes	2.3.4
NASA should enlist assistance from Native Village residents in location and recovery efforts.	Yes	2.3.4
Stronger outreach efforts and timely notification of launches to Native Villages may result in more items being located.	Yes	2.3.4

Opportunities for Future Involvement

During the preparation of this *PFRR EIS*, NASA will provide several additional opportunities for public and stakeholder involvement. The general public will have the opportunity to review how NASA addressed the concerns expressed during the scoping meetings for this EIS and the 2010 EA. Citizens, tribes, and government representatives will be invited to express their viewpoints, ask questions, and voice additional concerns at public meetings on this draft EIS, as well as through the same means offered to submit comments during the scoping period.

The *Final PFRR EIS* is planned for completion in the summer of 2013. As draft and final versions of the *PFRR EIS* are released, Notices of Availability will be published in the *Federal Register*, local newspapers, and on the internet to ensure the public is aware of the document's progress. Comments may be submitted through multiple means, including in writing, electronically via email (Joshua.A.Bundick@nasa.gov), and through the project website (http://sites.wff.nasa.gov/code250/pfrr_eis.html).

1.5 NASA'S FUTURE USE OF THIS EIS

As this EIS evaluates an ongoing (*e.g.,* annual) range of activities, it is possible that either the proposed action or the environmental context could change in the future from what is considered in this document. Accordingly, NASA has an ongoing duty to evaluate the environmental aspects of its SRP at PFRR. To satisfy this obligation, and consistent with current practice, NASA would perform an annual evaluation of its proposed future actions at Poker Flat. If both the proposed action and environmental conditions are within the scope of this EIS, the analysis and final determination would be documented in a Memorandum for the Record to be kept in the official project files. If the analysis finds that differences could result in potential impacts are outside the scope of this EIS, further NEPA documentation would be prepared before taking the action.

This approach is especially relevant to proposals for non-winter launches. Given that the probability and potential consequences of wildfire resulting from non-winter launches, is, for the most part, not analyzed in detail in this EIS, any future proposals for such launches would require the preparation of a more focused, mission-specific NEPA document in consultation with land managers prior to approval.

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CHAPTER 2

DESCRIPTION AND COMPARISON OF ALTERNATIVES

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2. DESCRIPTION AND COMPARISON OF ALTERNATIVES

This Chapter describes the National Aeronautics and Space Administration's Sounding Rockets Program, the proposed action, and the alternatives for the Poker Flat Research Range located near Fairbanks, Alaska.

As discussed in Chapter 1, the National Aeronautics and Space Administration (NASA) is analyzing its continued use of the Poker Flat Research Range (PFRR) as part of the Sounding Rockets Program (SRP) in this *Draft Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS).* Five alternatives, including a No Action Alternative, are being evaluated. Each of the alternatives involves continuation of launches from PFRR in much the same manner as has been done in the past with the key difference being the levels of effort to locate and recover newly and historically expended flight hardware from downrange lands. Two alternatives also incorporate restrictions in future launch trajectories.

How this Chapter is Organized

This chapter of the EIS is intended to provide the reader both an understanding of typical NASA sounding rocket operations at PFRR and the alternatives considered. Section 2.1 provides an overview of NASA sounding rocket operations at PFRR, including details of past and present launches and launch vehicles, PFRR facilities and infrastructure, and a discussion of typical flight and recovery activities. These PFRR operational components provide the context for the development of alternatives and can be considered common features of all alternatives considered in detail in this EIS, including the No Action Alternative.

Sections 2.2, 2.3 and 2.4 are dedicated to the discussion of alternatives that NASA considered for continuing its operations at PFRR, both those that are analyzed in detail and those that were considered but dismissed from further evaluation. The final component of this chapter is Section 2.5, which summarizes potential environmental impacts of each alternative evaluated in detail. This table, drawing upon information presented in Chapter 4, is provided in a comparative format such that the reader can readily identify differences in how each alternative may affect a particular resource area.

The principal information related to PFRR is based on the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* **(NASA 2000a)**.

2.1 POKER FLAT RESEARCH RANGE

PFRR is located in interior of Alaska near Fairbanks, approximately 1.5 degrees below the Arctic Circle at 65°2' N latitude and 147°5' W longitude. The facility consists of approximately 2,100 hectares (5,200 acres) on Steese Highway (Alaska Route 6) in the village of Chatanika, approximately 48 kilometers (30 miles) northeast of Fairbanks (see **Figure 2–1**). Directly north of PFRR are its downrange flight zones, over which rockets are launched and within which spent stages and payloads impact the ground.

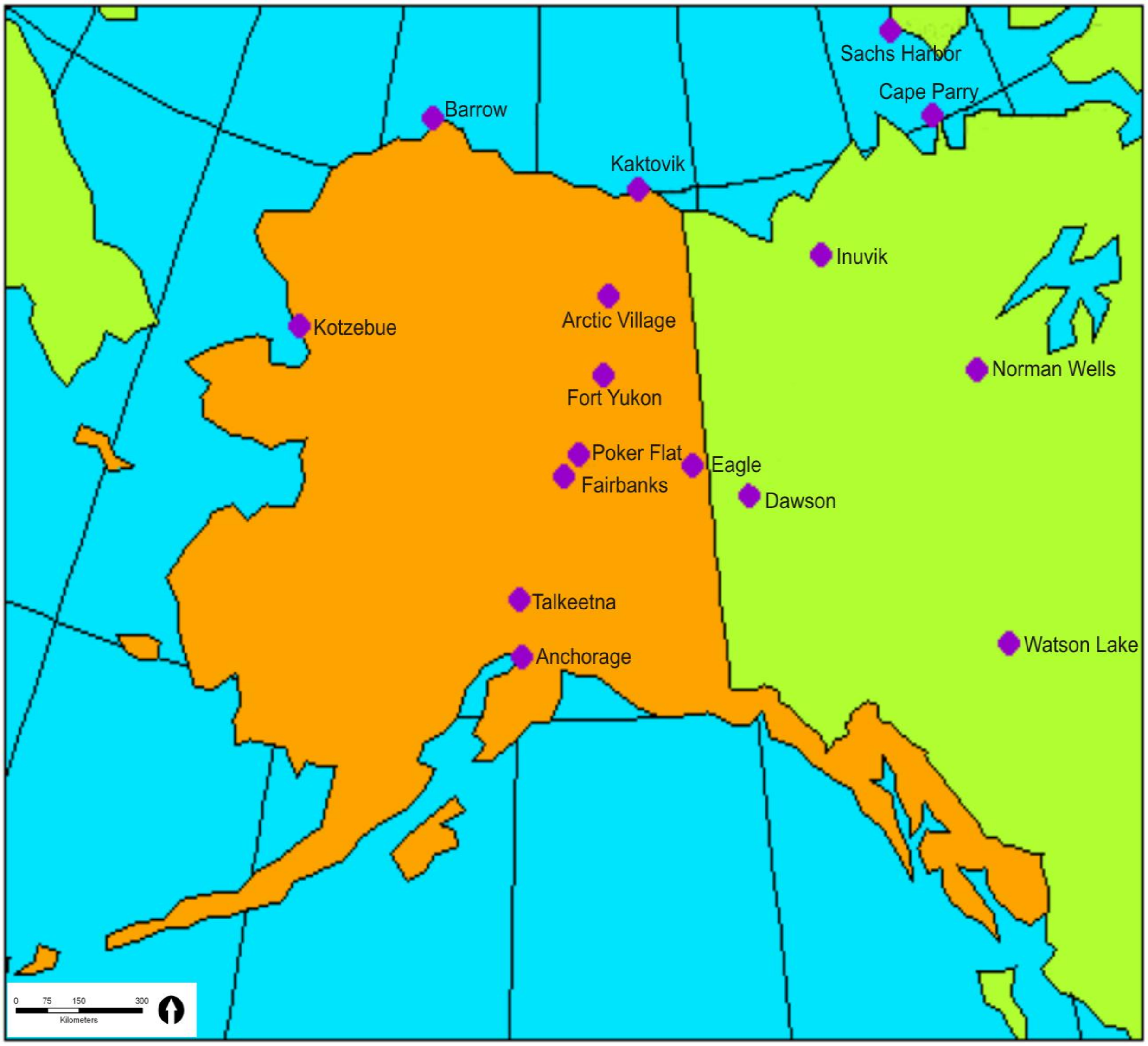


Figure 2–1. Poker Flat Research Range Vicinity Map

Since the late 1960s, NASA and other government agencies have launched suborbital rockets from PFRR **(Davis 2006)**. While PFRR is owned and managed by the Geophysical Institute of University of Alaska–Fairbanks (UAF), since the 1980s, NASA SRP has provided sole funding support to PFRR.

PFRR is a fully equipped and operational rocket launch complex that includes five rocket pads, a blockhouse, communication facilities, fire control and safety functions, payload and vehicle storage and assembly buildings, a clean room, geophysical monitoring and optical measurement instrumentation, radar and telemetry sites, downrange science monitoring sites, and administrative and miscellaneous support facilities. This equipment is discussed in detail in Section 2.1.4.

2.1.1 PFRR Launch History

NASA Launches

Since 1969, NASA has launched 219 sounding rockets at PFRR, including approximately 33 single-stage rockets, 149 two-stage rockets, 18 three-stage rockets, and 19 four-stage rockets. **Table 2–1** summarizes these launches. In the past 10 years, NASA SRP has averaged approximately four rockets launched per year at PFRR.

Table 2–2 and **Figure 2–2** summarize the types and characteristics of NASA rockets both currently in use and historically used at PFRR. Greater detail on each of the rockets currently used by NASA SRP at PFRR can be found in the *NASA Sounding Rocket Program Handbook* **(NASA 2005)**, as well as Section 2.2 of the *SRP SEIS* **(NASA 2000a)**. Appendix F of the *NASA Sounding Rocket Program Handbook* contains descriptions of each of the sounding rockets currently used by NASA. The *SRP SEIS* includes the rocket and stage masses, composition, flight characteristics, propellants, and rocket exhaust emissions.

Table 2–1. Sounding Rockets Launched by NASA from Poker Flat Research Range

Sounding Rocket (Numerical Type)	Number of Missions	Number of Stages (without payload)
Strypi (12)	1	2
Nike-Apache (14)	3	2
Super Arcas (15)	10	1
Nike-Tomahawk (18)	63	2
Black Brant V (19 & 21)	9	1
Nike-Black Brant (27)	2	2
Terrier-Malemute (29)	10	2
Orion/Improved Orion (30)	14	1
Nike-Orion (31)	12	2
Taurus-Orion (33)	16	2
Taurus-Tomahawk (34)	10	2
Black Brant X (35)	15	3
Black Brant IX (36)	14	2
Taurus-Nike-Tomahawk (38)	1	3
Black Brant XI (39)	2	3
Black Brant XII (40)	19	4
Terrier-Orion (41)	13	2
Total: 1-Stage Rockets	33	33
2-Stage Rockets	149	298
3-Stage Rockets	18	54
4-Stage Rockets	19	76
Summary	**219**	**461**

Source: Adapted from Davis 2006; NASA 2000a.

Table 2–2. Rocket Characteristics of Past and Current NASA SRP Launches at PFRR

Rocket Platform Name (Designation)	No. Stages	Date Range for Use at PFRR	Diameter		Length, Rocket + Payload		Approximate Mass, Rocket + Payload		Approximate Range		Approx. Flight Time (min)
			m	ft	m	ft	kg	lbs	km	mi	
Rockets No Longer In Service											
Super Arcas	1	1976–1986	0.11	0.4	2.50–2.80	8.2–9.0	42	93	60	37	5
Nike-Orion	2	1981–1995	0.42/0.36	1.4/1.2	8.1–8.8	27–29	1,400	3,090	30–120	19–75	5
Nike-Tomahawk	2	1969–1995	0.42/0.23	1.4/0.8	15	49	900	2,000	150–300	93–190	10
Taurus-Tomahawk	2	1979–1985	0.58/0.23	1.9/0.8	9.7	32	1,700	3,700	250–400	160–250	13
Taurus-Orion	2	1981–2002	0.58/0.36	1.9/1.2	12	40	2,000	4,400	60–150	37–93	10
Terrier-Malemute	2	1977–1986	0.46/0.41	1.3/1.5	12	39	1,700	3,700	200–300	120–190	10–18
Nike-Black Brant	2	1992–1995	0.42/0.44	1.4/1.4	14	46	2,000–2,400	4,400–5,300	100–300	62–190	6–18
Taurus-Nike-Tomahawk	3	1984	0.58/0.42/0.23	1.9/1.4/0.8	16	52	2,300–2,400	5,070–5,300	180–400	110–250	15
Rockets Currently In Use											
Orion	1	1985–Present	0.36	1.2	4.60–5.30	15–17	460	1,000	25–50	16–31	5
Black Brant V	1	1972–Present	0.44	1.4	10–11	33–36	1,500	3,300	80–200	50–120	10–15
Terrier-Orion	2	2003–Present	0.46/0.36	1.2/1.5	11	36	1,400	3,100	80–350	50–220	10–13
Black Brant IX	2	1982–Present	0.46/0.44	1.5/1.4	13–16	43–52	2,300–2,600	5,100–5,700	50–150	31–93	8–10
Black Brant X	3	1982–Present	0.46/0.44/0.44	1.5/1.4/1.4	16	52	2,600–2,800	5,700–6,400	200–500	120–310	18
Black Brant XI	3	1990–Present	0.76/0.58/0.44	2.5/1.9/1.4	21	69	4,900–5,300	10,800–11,700	300–500	190–310	10–15
Black Brant XII	4	1990–Present	0.76/0.58/0.44/0.44	2.5/1.9/1.4/1.4	18–23	59–75	5,200–5,700	11,500–12,600	300–1,200	190–750	10–20

Key: ft=feet; kg=kilograms; km=kilometers; lbs=pounds; m=meters; mi=miles; min=minutes; NASA=National Aeronautics and Space Administration; PFRR=Poker Flat Research Range; SRP=Sounding Rockets Program.

Source: Davis 2006.

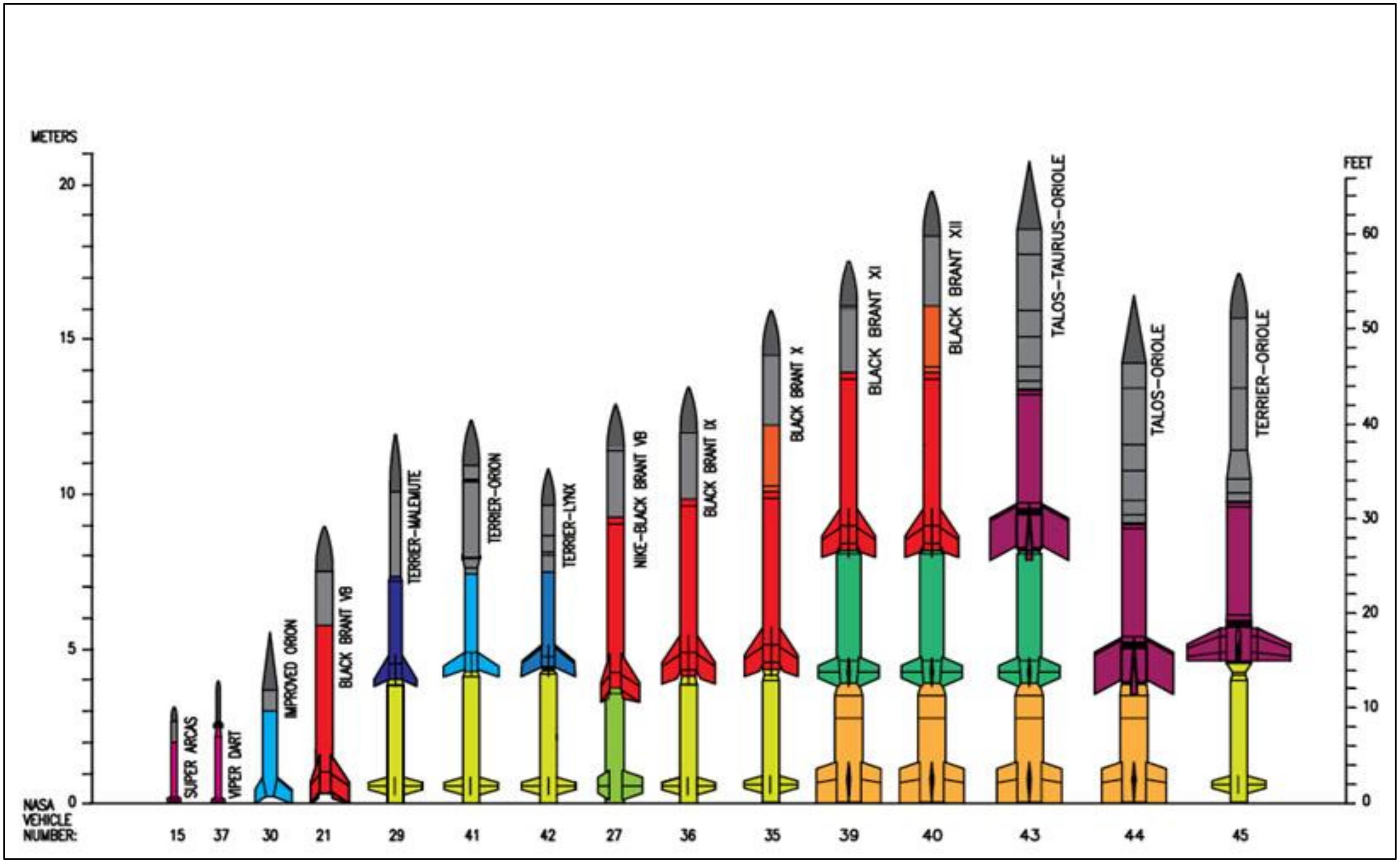


Figure 2–2. Representative Launch Vehicles, Ranging From a Single-Stage Orion to a Four-Stage Black Brant XII

Historically at PFRR, the majorities of launches have occurred during the winter months; within the last 10 years all launches have taken place between January and April, and this would likely continue (see **Figures 2–3** and **2–4**). Launches in other seasons are not frequent, but possible. Additional concerns, including wildfire and airspace congestion, would need to be addressed for launches outside of the winter months.

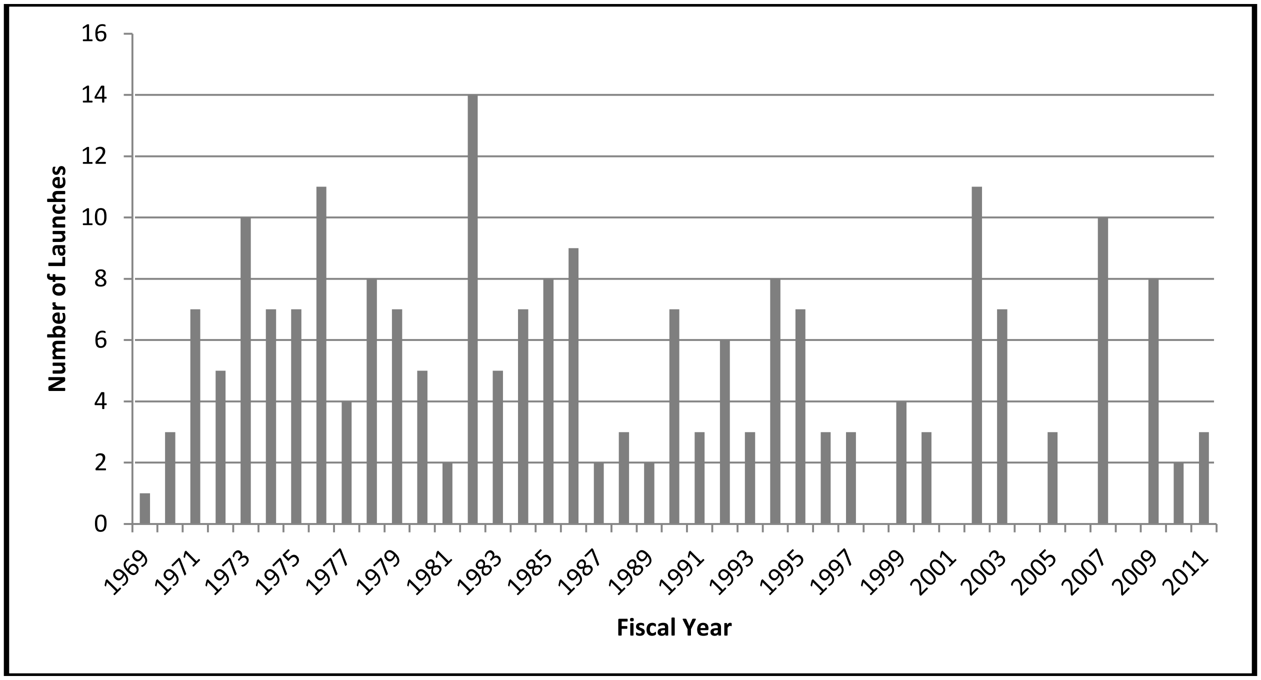


Figure 2–3. Sounding Rockets Launched by NASA from Poker Flat Research Range by Fiscal Year

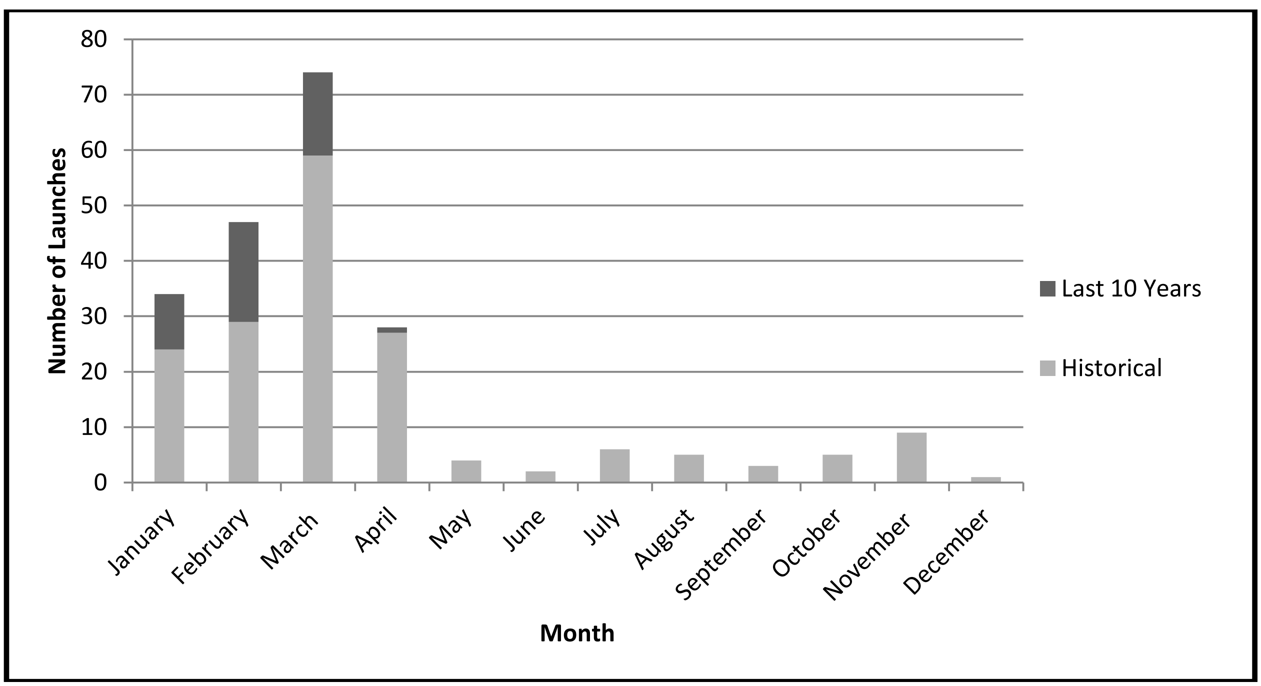


Figure 2–4. Numbers of Sounding Rocket Program Launches per Month

Non-NASA Launches

In addition to enabling research conducted by NASA, PFRR has also supported approximately 116 suborbital launches sponsored by other government, commercial, and academic organizations. These launches occurred primarily during the 1970s and early 1980s, with the most recent non-NASA mission occurring in 1995 (see **Figure 2–5**).

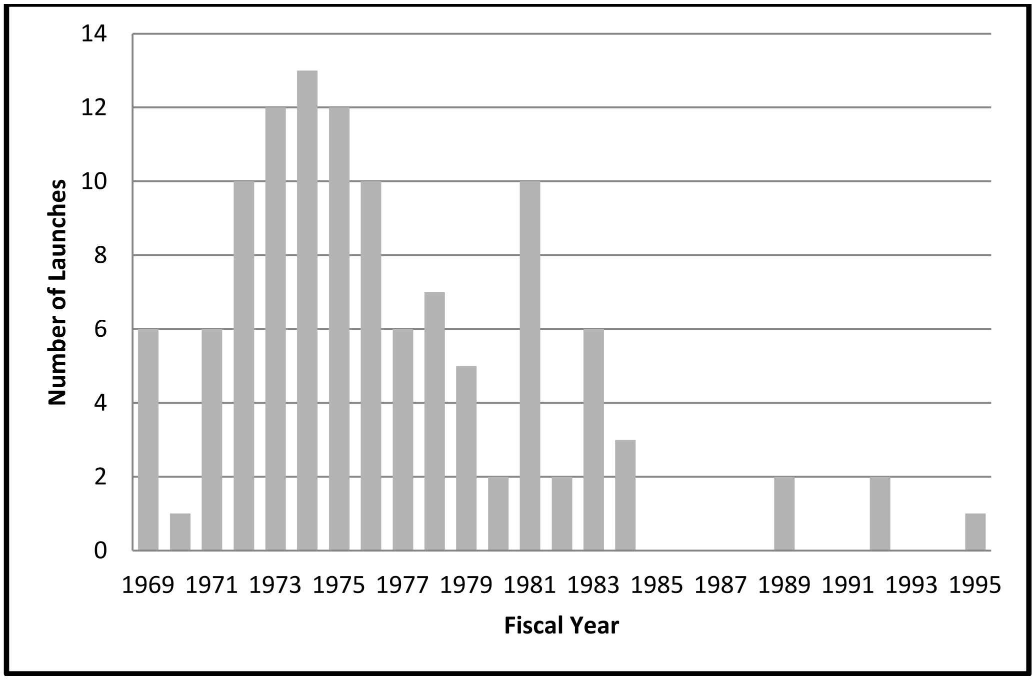


Figure 2–5. Non-NASA Sounding Rocket Launches from PFRR

2.1.2 Future NASA Launches

2.1.2.1 *Launch Vehicles*

General

All rocket motors launched by NASA at PFRR are spin stabilized, non-guided, and solid fueled. Propellants typically include ammonium perchlorate and aluminum or nitrocellulose and nitroglycerine. Section 2.2 of the *SRP SEIS* **(NASA 2000a)** defines these propellants and their exhaust products in full detail. These rocket motors are stacked and configured to meet scientific constraints driven by payload size and target altitude desired by the researchers. Individual motors range in size from 36 to 79 centimeters (14 to 31 inches) in diameter and are 1.9 to 5.7 meters (76 to 223 inches) long. Each stage of the vehicle comes back down in one piece with fins and all inter-stage hardware attached. The current inventory of rocket motors used by SRP has steel cases and steel, aluminum, or similar metallic alloy fins and attachment hardware. Future rocket motor cases may be made of composite materials such as fiberglass, Kevlar, or similar materials. However, the dimensions and overall appearance would remain consistent with current inventory for the foreseeable future. Due to the nature of solid rocket motors, all propellant is burned once ignited; therefore, only trace residual amounts remain on each stage after flight.

Specific Vehicles

In the future, NASA would propose to launch the vehicle configuration that would meet range safety considerations and the scientific needs of the mission, which could be any vehicle in its "stable." However, to reduce repetition of specific vehicle details that are provided in the *SRP SEIS* and to focus on the vehicles that would most likely be launched in the future, this EIS only provides a detailed description of the Terrier-Improved Orion and the Black Brant XII. Not only were the two vehicles the most frequently launched during the past 10 years of operation at PFRR, but the Black Brant XII is the largest in terms of rocket and payload size, and would therefore be expected to have the greatest environmental impacts. Details regarding the other SRP launch vehicles are located in Section 2.2 of the *SRP SEIS* and are incorporated by reference into this section.

Terrier-Improved Orion (41.XXX)

The Terrier-Orion rocket system is a two-stage rail-launched rocket system that utilizes a surplus U.S. Navy Terrier Mk 12 Mod 1 or Mk 70 for the first stage and a surplus Army Improved Orion motor for the second stage (see **Figures 2–6** and **2–7**). The Terrier motor is 46 centimeters (18 inches) in diameter and is configured with 0.23 or 0.45-square-meter (2.5 or 4.8-square-foot) fin panels arranged in a cruciform configuration. The Orion motor is 36 centimeters (14 inches) in diameter and 279 centimeters (110 inches) long. The vehicle is typically configured with spin motors and the total weight of this configuration, excluding the payload, is approximately 1,318 kilograms (2,900 pounds).

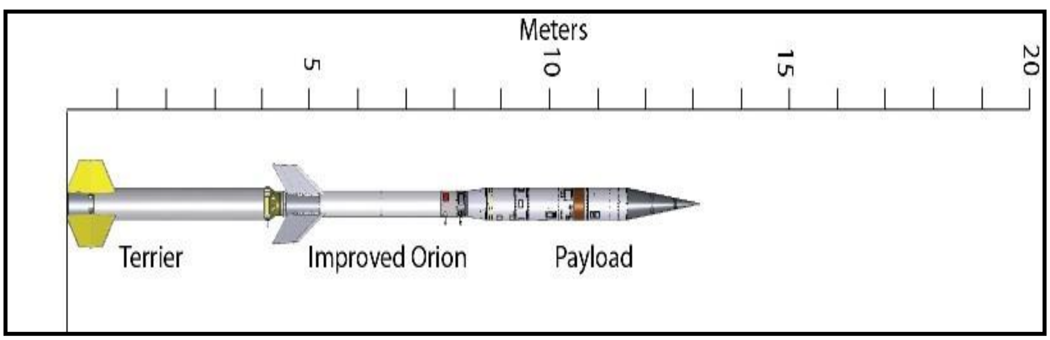


Figure 2–6. Terrier-Improved Orion Configuration

The Terrier propellant weighs 535 kilograms (1,177 pounds) and is of the nitrocellulose/nitroglycerin family, with added lead compounds and aluminum. The rocket exhaust emissions are mainly carbon monoxide, carbon dioxide, nitrogen, and water. They occur during the 5-second burning time over the altitude span from ground to 2 kilometers (1.24 miles). Terrier impact is about 1 kilometer (0.62 miles) from the launch pad with a spent rocket weight of 302 kilograms (664 pounds) **(NASA 2000a)**.

The Improved Orion propellant weighs 294 kilograms (647 pounds) and is a mix of ammonium perchlorate, polyurethane, and nitroguanadine. The rocket exhaust emissions are mainly hydrogen chloride, water, carbon monoxide, carbon dioxide, and aluminum oxide. They occur during the 25-second burning time over a typical altitude span from 10 to 40 kilometers (6.2 to

24.8 miles). The spent rocket motor weight is 145 kilograms (320 pounds) at final impact about 80 to 350 kilometers (50 to 218 miles) downrange.

Figure 2–7. Terrier-Improved Orion Launch Vehicle

Payload configurations supported by this vehicle include 36-centimeter (14-inch) and bulbous 44-centimeter (17.25-inch) diameters. Payload weights ranging from 91 to 367 kilograms (200 to 800 pounds) can achieve altitudes of approximately 80 to 200 kilometers (50 to 124 miles).

Black Brant XII (40.XXX)

The largest vehicle typically launched at PFRR is the four-stage Black Brant XII (see **Figures 2–8** and **2–9**), which is designed for carrying a variety of payloads to very high altitudes. Flight times vary from 10 to over 20 minutes, and impact ranges vary from 300 to over 1,200 kilometers (180 to over 930 miles).

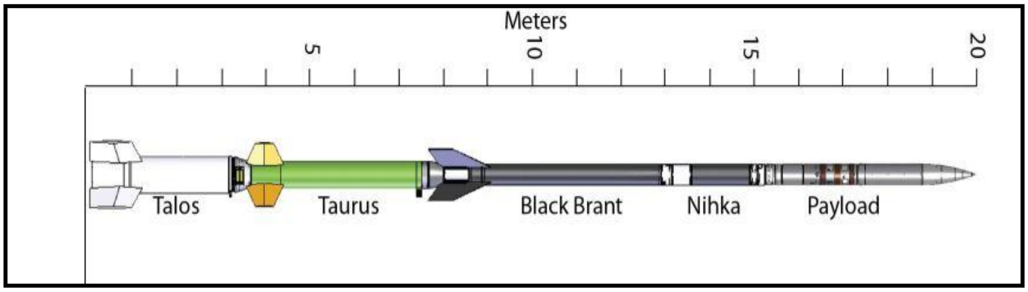


Figure 2–8. Black Brant XII Configuration

Source: NASA 2005.

Figure 2–9. Black Brant XII Launch Vehicle

The first stage is a modified Talos rocket motor, which is approximately 3.4 meters (133 inches) long, with a diameter of about 79 centimeters (31 inches). Four fins are arranged at the aft end in a cruciform configuration, each approximately 0.64 square meters (6.9 square feet) in area. The Talos propellant weighs 1,300 kilograms (2,800 pounds) and is of the nitrocellulose/ nitroglycerin family with lead compound additives. The rocket exhaust emissions are mainly carbon dioxide, carbon monoxide, nitrogen, and water. They occur during the 6.4-second burning time over the altitude span from ground to about 2 kilometers (1.2 miles). Talos impact is about 1 kilometer (0.6 miles) from the launch pad, with a spent rocket weight of 809 kilograms (1,800 pounds).

The second stage Taurus motor is 4.2 meters (165 inches) long, with a principal diameter of about 58 centimeters (23 inches). Each Taurus fin is 0.45 square meters (4.8 square feet) in area. The weight of the booster system (with hardware) is about 1,400 kilograms (3,000 pounds), including 760 kilograms (1,700 pounds) of propellant, which is of the nitrocellulose/ nitroglycerin family, with lead compounds and graphite as additives. The rocket exhaust emissions are mainly carbon monoxide, carbon dioxide, water, and nitrogen. They occur during the 3.5-second burning time over the altitude span from 4 to 6 kilometers (2.5 to 3.7 miles). Taurus impact is approximately 3 kilometers (1.9 miles) from the launch pad, with a spent rocket weight of 602 kilograms (1,300 pounds).

The Black Brant V rocket motor has been modified for use as the third stage. The primary diameter of the Black Brant V is about 44 centimeters (17 inches), and it is 5.3 meters (210 inches) long. The loaded weight of the motor, including hardware, is about 1,271 kilograms (2,803 pounds), which includes about 1,020 kilograms (2,200 pounds) of propellant, which is of the ammonium perchlorate/aluminum/plastic binder type with small amounts of carbon black, iron, and sulfur. The rocket exhaust emissions consist mainly of aluminum oxide, carbon monoxide, hydrogen chloride, nitrogen, and water. They occur during the 33-second burning time over the altitude span from 10 to 59 kilometers (6.2 to 37 miles). The Black Brant V impact is approximately 50 to 100 kilometers (31 to 62 miles) from the launch pad, with a spent rocket weight of 270 kilograms (590 pounds).

The Nihka rocket motor is used as the fourth stage on the Black Brant XII vehicle system. The primary diameter is about 44 centimeters (17 inches) and the length is about 1.90 meters (76 inches). The loaded motor weight is 408 kilograms (900 pounds), which includes 320 kilograms (700 pounds) of propellant of the ammonium perchlorate/aluminum/plastic binder type, with carbon black, iron, sulfur, and ferric oxide additives. The rocket exhaust emissions are mainly aluminum oxide, hydrogen chloride, carbon monoxide, water, and nitrogen. They occur during the 18-second burning time over the altitude span from 96 to 150 kilometers (60 to 96 miles), with a spent rocket weight at final impact of 93 kilograms (200 pounds).

The standard payload configuration for the Black Brant XII vehicle is about 44 centimeters (17 inches) in diameter with a 3:1 ogive nose shape. Payload length and weight limits for the Black Brant XII are determined on a case-by-case basis.

2.1.2.2 *Payload Hardware and Experiments*

General

There are a variety of payloads and experiments that are flown on SRP missions. These payloads/experiments range in size from 0.76 to 5.3 meters (30 to 210 inches) long, are of similar diameter to the rocket motor on which they are flown, and weigh from less than 45 kilograms (100 pounds) to over 500 kilograms (1,100 pounds). They all utilize mechanical structures made of a variety of materials, including aluminum, steel, magnesium, other lightweight metals, or occasionally composites such as fiberglass, graphite/epoxy, etc. Internal components consist mainly of electronic subsystems, batteries, pressure systems (pressure vessels, tubing, regulators, valves, etc.), and a variety of sensors and instruments such as magnetometers, optical devices, and antennas of varying shapes and sizes. A drawing of a typical payload before and after deployment is shown below in **Figures 2–10** and **2–11**.

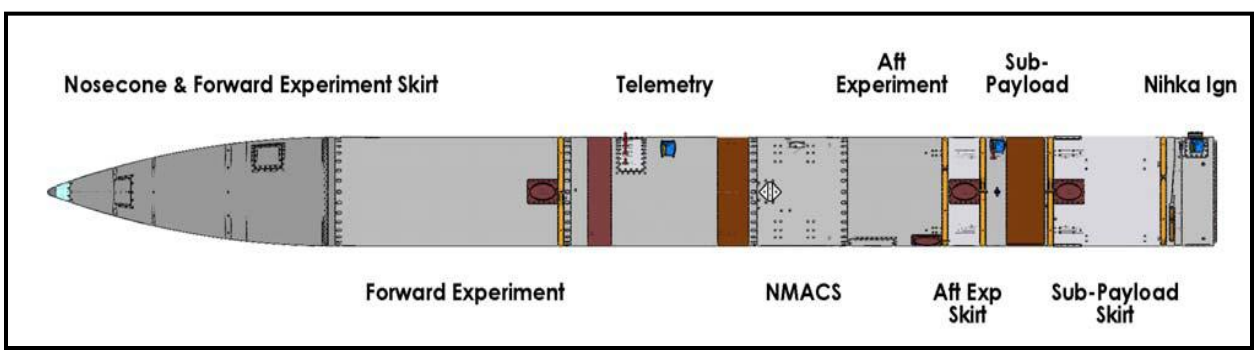


Figure 2–10. Typical Sounding Rockets Payload with Nose Cone

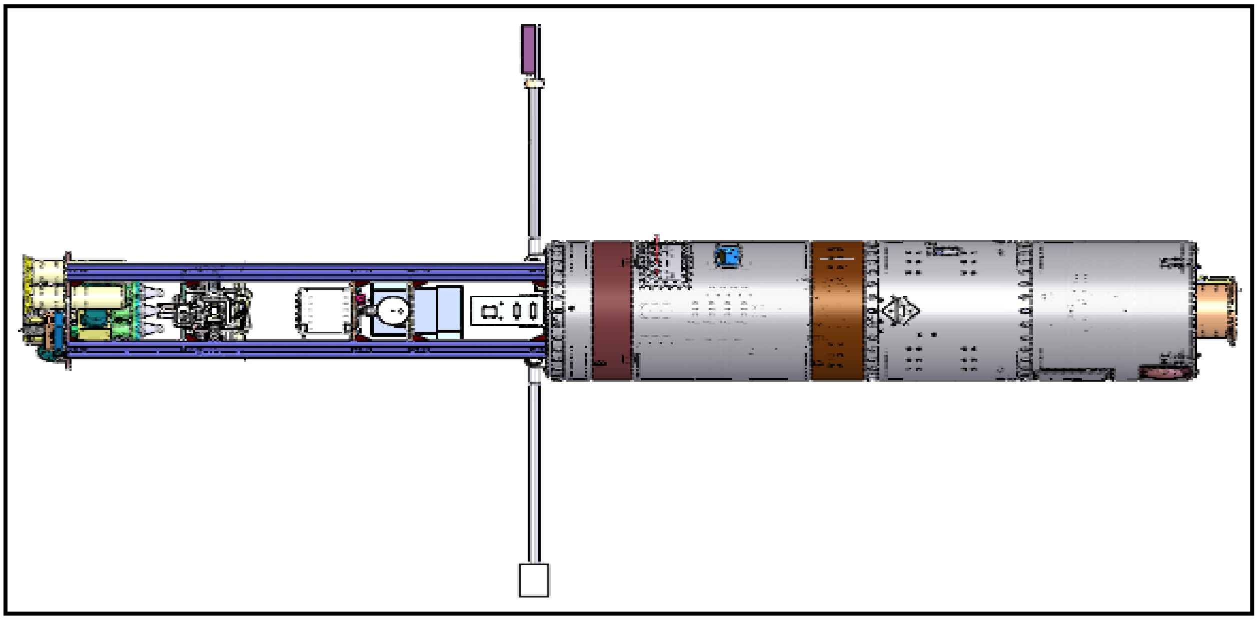


Figure 2–11. Typical Sounding Rockets Payload Without Nose Cone

The payloads often contain deployable devices, such as nose cones used to cover sensitive electronic instruments during ascent, releasable doors, antennas, de-spin weights, cables, and other similar components. In many cases, a payload flown on a single rocket will be separated in flight into multiple pieces, each designed to carry out a specific scientific objective.

Payloads with Tracers for High-Altitude Dispersal

Some payloads may carry chemical "tracers" that are intentionally dispersed at high altitude to study high-altitude phenomena and to develop a better understanding of the processes that occur at those altitudes. These releases have typically been in the ionosphere, or thermosphere, a layer of the Earth's atmosphere located at altitudes from 80 to beyond 1,000 kilometers (approximately 50 to beyond 620 miles).

These tracers are often employed in the observation and measurement of upper atmospheric winds. The tracer is released by the sounding rocket along its trajectory forming a trail, with the drift of the trail providing the wind profile. Such wind profiles are determined using triangulation by tracking the trails with cameras from two or more ground-based sites (*e.g.,* Fort Yukon, Coldfoot). Following release, the trails are generally visible for less than 20 minutes. In recent years, these measurements have been used almost exclusively as one component of multi-instrument investigations designed to study specific upper-atmospheric phenomena **(Larsen 2002)**.

The tracers that have been used most extensively for sounding rocket wind measurements are sodium, lithium, and trimethyl aluminum (TMA). Sodium and lithium releases are produced by burning a mixture of thermite (titanium diboride, the reaction product of boron and titanium) and the metal to produce a vapor. The tracers are visible due to green and red emissions for sodium and lithium, respectively. Since the emissions only occur when the vapor is illuminated, wind measurements can only be made at dusk or dawn when the trails are illuminated by the sun but the observing sites on the ground are in darkness so that the trails are visible **(Larsen 2002)**.

TMA, on the other hand, is a pyrophoric liquid that reacts on contact with oxygen to produce chemiluminescence. When illuminated by the sun in twilight, the trails produce an additional blue emission. The advantages of TMA as a chemical tracer are that it can be used anytime during the night. Accordingly, TMA has become the most commonly used tracer after it was first tested in the early 1960s and the majority of the release-derived wind measurements made since then have used TMA **(Larsen 2002)**.

Other metallic elements, including barium, strontium, and samarium have been employed onboard sounding rockets for observing upper-atmospheric phenomena. Barium and strontium are typically used in combination, as each presents the opportunity to observe different phenomena (charged particle motion for barium, neutral particles motion for strontium). Samarium is a tracer of both the charged and neutral particles. To provide the reader some perspective, compounds containing several of these elements are commonly used in non-science-related applications requiring luminescence. In particular, barium creates the green color in fireworks whereas strontium produces the red color.

In the past 10 years of launches at PFRR, all 16 tracer release payloads have contained TMA; however, the use of additional tracers (as described above) is likely in the future **(Larsen 2011)**. As handling these materials may be hazardous while on the ground, NASA follows strict safety procedures during launch operations. Uses of these materials are monitored by NASA's independent safety organization and are rigorously addressed in applicable NASA documentation, including project Ground Safety Plans.

Payloads with Radioactive Sources

All recent SRP flights with radioactive sources have been made or are planned to be made from White Sands Missile Range in White Sands, New Mexico. Although a review of available records indicates that no such flights have occurred from PFRR in the past **(Simpson 2012)**, nor are any envisioned in the near future, the potential exists for a researcher to propose flying a payload that would carry small quantities of encapsulated radioactive materials for instrument calibration or similar purposes. The amount and type of radioactive material that can be carried are strictly limited by the approval authority level delegated to the NASA Nuclear Flight Safety Assurance Manager in accordance with NASA Procedural Requirement 9715.2. As part of the approval process, the spacecraft program manager must prepare a Radioactive Material Report that describes all of the radioactive materials to be used on the payload. The NASA Nuclear Flight Safety Assurance Manager would certify that preparation and launching of routine payloads carrying small quantities or radioactive materials would not present a substantial risk to public health or safety. All missions carrying radioactive sources would be required to obtain the necessary NASA Nuclear Flight Safety Assurance Manager concurrence/approval prior to launch.

2.1.2.3 *Launch Frequency*

Future NASA SRP missions at PFRR could average from two to four launches every year. It is expected that no more than eight multi-stage suborbital rockets would be launched in any one year from PFRR under any action alternative. The eight launches could be spread across 8 separate days or concentrated into only 2 or 3 separate days with multiple launches.

This launch frequency estimate is based upon the past 10 years of PFRR activity; this timeframe was selected to be representative of recent launch activity at PFRR and to demonstrate the anticipated future level of activity and resultant impact associated with SRP at PFRR. Sounding rocket launches at PFRR prior to this time were typically of shorter range and are therefore not representative of recent SRP activities at PFRR.

2.1.2.4 *Launch Season*

Future launches are expected to occur within the winter months, consistent with PFRR launch activity over the past 10 years. However, the potential for a researcher to propose an experiment during the non-winter months cannot be discounted. Furthermore, the potential environmental effects from such a launch would be highly mission-specific. Accordingly, this EIS provides a high-level discussion of issues that would require consideration during the planning of a non-winter launch. In the event that a future summer launch were to be proposed, a more detailed, supplemental NEPA analysis would be required before approval.

2.1.3 PFRR Launch and Support Facilities

Geographically, PFRR comprises three separate areas at the launch site: the Lower, Middle, and Upper Ranges, as shown in **Figure 2–12 (NASA 2000a)**.

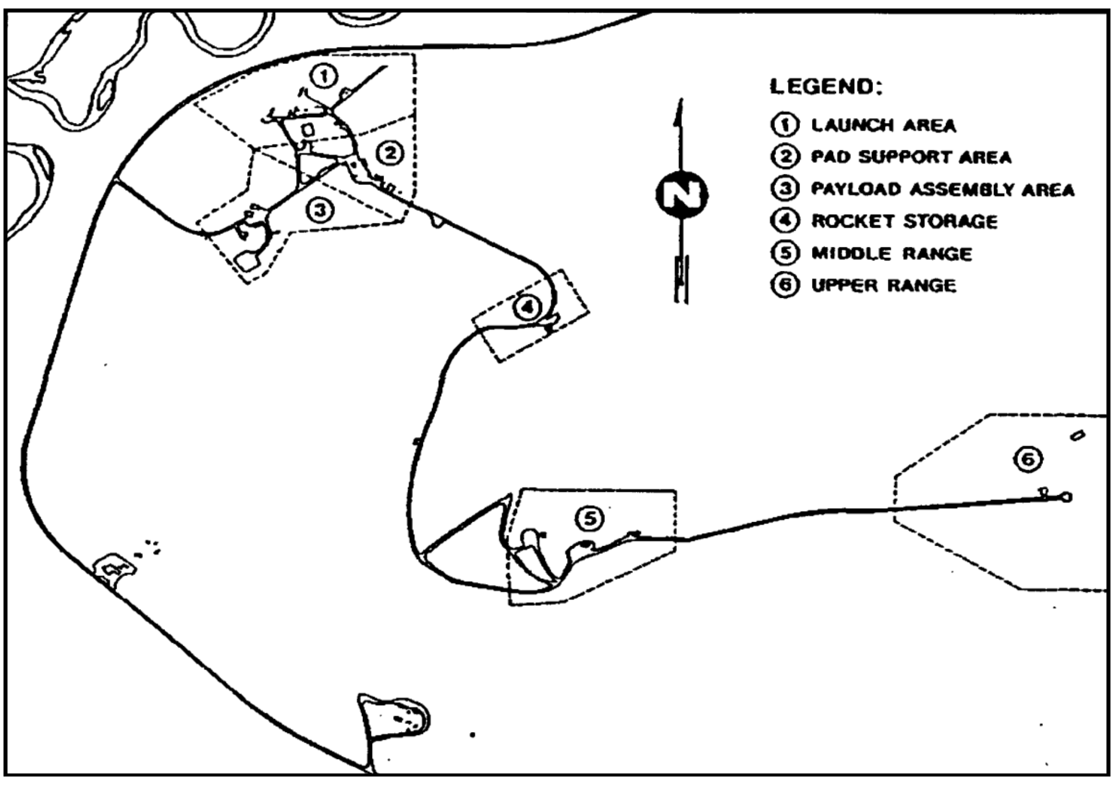


Figure 2–12. Poker Flat Research Range Areas

Lower Range

The ***Lower Range*** at PFRR includes range offices, rocket launch facilities, the blockhouse, pad support, payload assembly facilities, and a rocket storage building **(NASA 2000a)**. The area is relatively flat, with an average elevation of 200 meters (660 feet) above mean sea level (msl).

The range facilities include an operations and office building; a 12- by 15-meter (40- by 50-foot) launch-control blockhouse complex; a 15- by 15-meter (50- by 50-foot) payload assembly building with a Class-100 clean room; an 87-meter (290-foot) instrumented meteorological tower; minicomputers to calculate wind weight parameters; and other buildings for rocket storage, assembly, and various operations and maintenance functions.

The facilities located at the Lower Range include the Payload Assembly Area, the Launch Support Area, and the Launch Area.

The ***Payload Assembly Area*** contains the PFRR administrative and support function and includes the Range Office Building, a single-story structure, and the C-band radar installation. A concrete shelter is located at the base of the radar tower for occupation during critical launch periods. The Payload Assembly Building is approximately 6.7 meters (22 feet) tall and approximately 508 square meters (5,500 square feet) in size (see **Figures 2–13** and **2–14**). South of the Payload Assembly Building is the Stratosphere-Troposphere (S-T) radar installation **(NASA 2000a)**.

Figure 2–13. Payload Assembly

Figure 2–14. Payload Assembly Building

The ***Launch Support Area*** includes Rocket Assembly Buildings A and B, a communications building, tool crib, grader shed, warehouse, and machine shop. Rocket Assembly Building A and the Rocket Storage Facility are single-story structures (see **Figures 2–15** and **2–16**). The warehouse is a building that is used for equipment storage and light repair work.

Figure 2–15. Rocket Assembly Area

Figure 2–16. Rocket Storage Facility

Storage of high-energy materials presents the potential for hazard, and strict safety procedures are enforced at all locations of this area. In keeping with established safety practices, and to minimize the hazard, standards for minimum safe distances from inhabited buildings (explosive quantity distances) comply with NASA Safety Standard 8719.12 for explosives, propellants, and pyrotechnics **(NASA 2010a)**.

The ***Launch Area*** at PFRR comprises a control center/blockhouse and five rocket pads (shown below) arranged concentrically around the blockhouse (see **Figures 2–17** and **2–18**). The blockhouse is approximately 190 square meters (2,000 square feet) in size. It is a single-story, aboveground concrete structure with an earthen embankment. The blockhouse functions as a mission control center for all five launch pads. Each of the pads is equipped with a single launcher **(NASA 2000a)**.

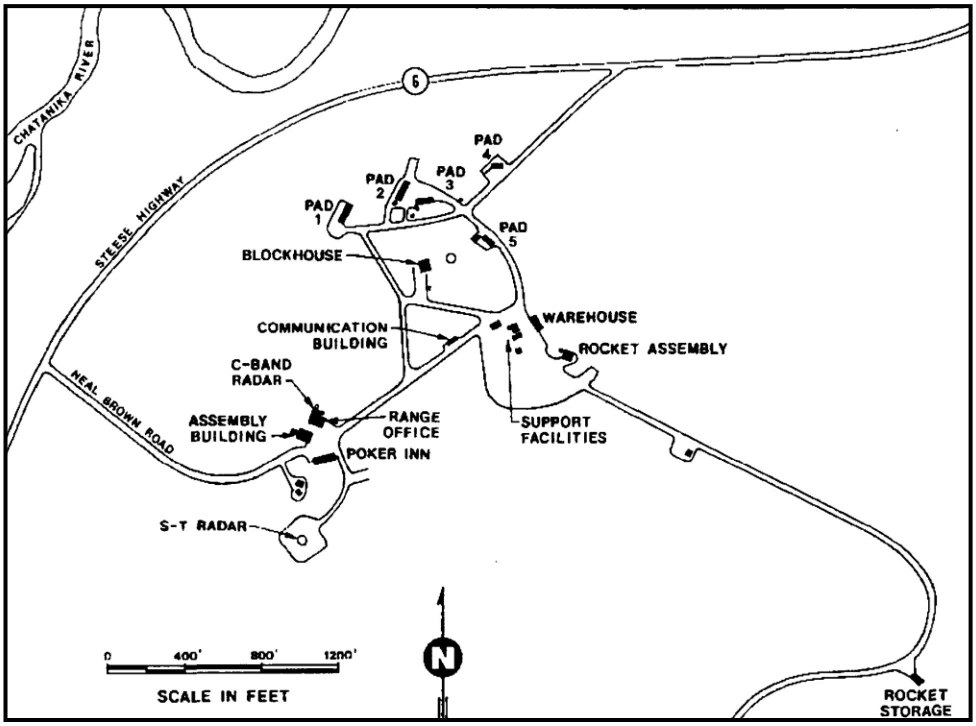


Figure 2–17. Poker Flat Research Range Launch Area Facilities

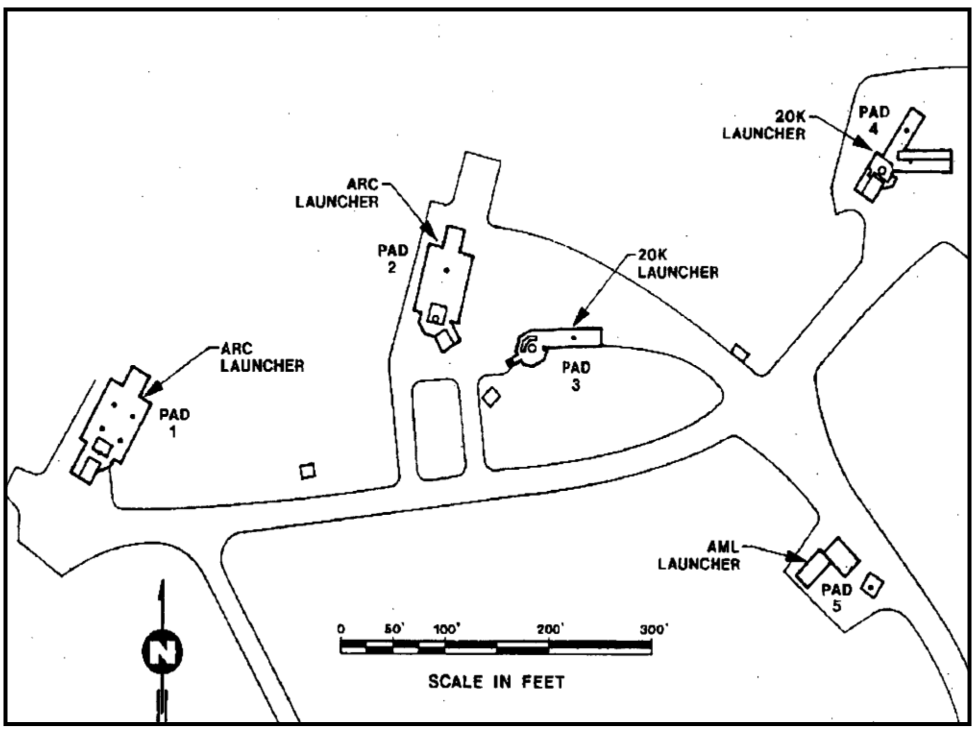


Figure 2–18. Poker Flat Research Range Launch Vicinity

Launch Pads No. 1 and No. 2 are equipped with MRL 7.5K launchers capable of handling launch vehicles ranging from one to several stages (see **Figure 2–19**). The MRL launcher is capable of launching a wide range of propulsion systems, including the Black Brant series of rockets, as well as combinations of Nike, Orion, Tomahawk, Taurus, Terrier, and Malamute rockets.

Figure 2–19. Poker Flat Research Range Launch Pads

Launch Pads No. 3 and No. 4 are equipped with AML 20K launchers capable of handling launch vehicles ranging from one to several stages, including the Black Brant series, as well as combinations of Nike, Orion, Tomahawk, Taurus, Terrier, and Malemute rockets. An environmental shelter is available at both launch pads to protect preflight preparation work on the 20K launcher (see **Figure 2–20**).

Figure 2–20. Launch Pad No. 4 with Retracted Environmental Shelter

Launch Pad No. 5 is equipped with an AML 4.3K twin boom launcher and is used to launch smaller rockets such as the Arcas and Super Loki.

Northeast of the ***Launch Area*** is the Poker Flat Incoherent Scatter Radar (PFISR). Funded by the National Science Foundation, PFISR is a phased array radar system that enables that ground-based investigation of upper atmospheric phenomena, including aurora. Since it began operation in 2006, several times it has provided direct support (*i.e.,* providing complementary measurements) to PFRR-launched sounding rockets.

Middle Range

The ***Middle Range*** at PFRR is the area where the telemetry complex and lidar [light detection and ranging] observatory are located. It is approximately 220 meters (700 feet) higher than the Lower Range and approximately 2.7 kilometers (1.7 miles) from the Lower Range. The telemetry complex comprises approximately 360 square meters (3,900 square feet) of enclosed area with a roof-mounted antenna. Several smaller buildings that house radar installations are adjacent to the telemetry area **(NASA 2000a)**.

Range telemetry support is provided by three S-band auto-track systems, incorporating a 2.4-meter (8-foot), an 11-meter (36-foot), and a 4.9-meter (16-foot) dish, provided by NASA and located on Middle Range. PFRR also contains a C-Band NASA radar for vehicle tracking, surveillance radar for local air traffic, and a meteorological Balloon Inflation Building. Additionally, the range has a Transportable Orbital Tracking System (TOTS) and the Redstone Antenna.

Upper Range

The ***Upper Range*** at PFRR is the area on the ridge top above the Lower and Middle Ranges. The area's top elevation is 500 meters (1,600 feet) msl.

The T. Neil Davis Science Operations Center is located at the Upper Range and houses magnetometers, relative ionospheric opacity meters (riometers), all-sky auroral cameras, a meridian-scanning photometer, three Fabry-Perot interferometers, and other observing instruments such as a low-light color television camera and video recorder for auroral research. Local tropospheric measurements are made at the Climate Change Monitoring Station. PF1 (Datalynx), a commercial venture used for satellite tracking, is also located at the Upper Range.

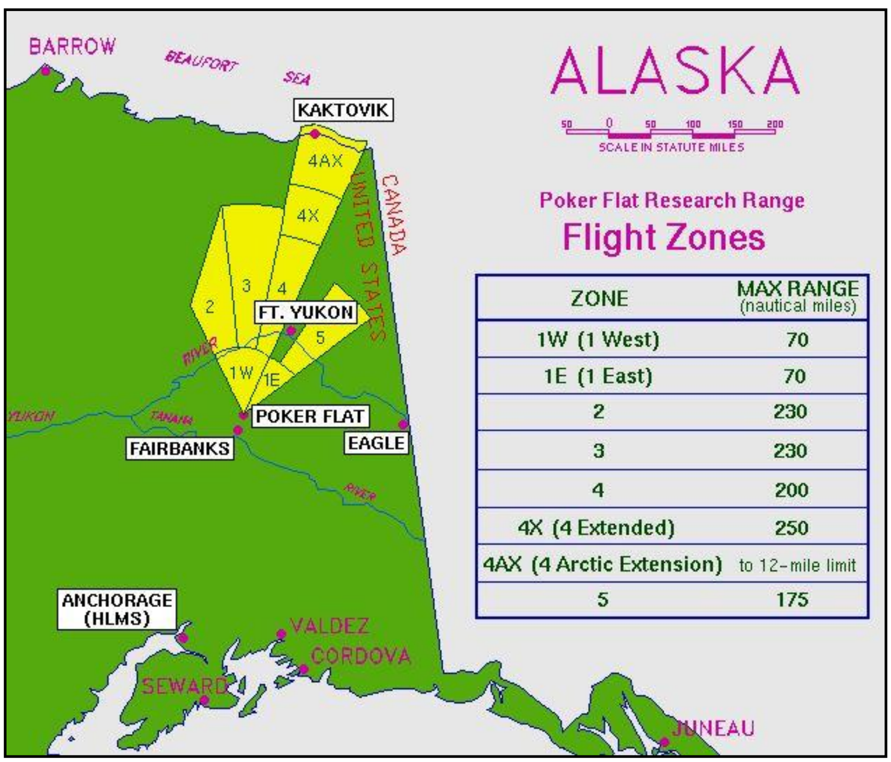
2.1.4 Downrange Support Facilities

PFRR maintains downrange observatories in Alaska at Fort Yukon, Toolik Lake, and Kaktovik (see **Figure 2–21**). As these facilities are land based, readily accessible, and "under" the airspace within which the sounding rockets fly, they enable inputs from both human observers and ground based research instruments (*e.g.,* magnetometers, all-sky cameras, lidars) to be relayed to the science operations center at PFRR, thereby permitting launches during optimum scientific conditions.

Figure 2–21. Downrange Observatories at Fort Yukon (left) and Kaktovik (right)

2.1.5 Launch Corridor and Flight Zones

Figure 2–22 illustrates flight zones that have been established for PFRR. All stages and payloads are expected to land within these designated flight zones. A more detailed discussion of downrange lands is located in Chapter 3, Section 3.2.2 of this EIS.



Source: UAF 2012.

Figure 2–22. Poker Flat Research Range Flight Zones

Directly north (downrange) of the launch site are the White Mountains National Recreation Area (NRA); Steese National Conservation Area – North Unit; Yukon Flats National Wildlife Refuge (NWR); Brooks Range; Arctic NWR; privately owned lands, including lands owned by Alaska

Native Regional Corporations; and the Arctic Ocean. The use of downrange landmasses is permitted by a series of agreements, Special Use Permits, and letters of understanding between the UAF Geophysical Institute and Alaska Native tribal governments, the U.S. Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS), and other agencies.

Ownership and administration of downrange lands has changed since the establishment of launch facilities at PFRR. Arctic National Wildlife Range was established in 1960, 9 years prior to PFRR. In 1980, Congress passed the Alaska National Interest Lands Conservation Act (ANILCA), which renamed the Range the Arctic National Wildlife Refuge, doubled its size, and designated 3.2 million hectares (7.9 million acres) of the original Range as Wilderness (now known as the Mollie Beattie Wilderness Area). Prior to 1980, the lands that make up Yukon Flats NWR were administered by BLM. ANILCA established Yukon Flats NWR, transferring administration of the lands from BLM to USFWS. Arctic NWR has issued permits for sounding rocket launches from PFRR since 1981, and Yukon Flats NWR since 1988. In its 2005 compatibility determinations for rocket and payload impact and recovery at Arctic and Yukon Flats NWRs, **(USFWS 2005a, 2005b)**, USFWS found the landing and recovery of rocket stages and payloads to be a compatible activity.

White Mountains NRA and Steese National Conservation Area, both BLM administered lands, were also established in 1980 by ANILCA. Historically, BLM has allowed PFRR to impact and recover sounding rockets and payloads on lands it administers.

2.1.6 Launch Area Operations

General

Each main SRP flight typically entails the following programmatic components:

1. Preflight activities, including receiving, storing, and inspecting rockets and assembling the scientific payload;
2. Assembling rockets and scientific payload to make up the launch vehicle, transporting the launch vehicle to the launch pad, mounting the vehicle to the launcher, and pointing the launcher;
3. Releasing meteorological balloons at regular intervals;
4. Series launching of two small test rockets nearby for radar (70-millimeter [0.3-inch]) and telemetry checkout/calibration;
5. Actual launching and surface-to-surface flight, lasting a matter of minutes;
6. Immediate post-flight activities, including search or recovery of the payload and spent stages, and storing of the launch equipment; and
7. Closure activities, such as restoring launch sites to their original condition.

A flow chart detailing events 1 through 6 above appears as **Figure 2–23**. This figure consists of two sheets, the first illustrating preflight actions 1 through 3, and the second, flight and post-flight actions 4 through 6. A three-stage launch vehicle was assumed. Sheet 1 of Figure 2–23 starts with actions leading to the mounting of the launch vehicle on the launcher and the pointing of the launcher in readiness for the launch. The last action on Sheet 1 is the launching of the twin test rockets, one after the other, for radar/telemetry checkout, about one-half hour before the main launch.

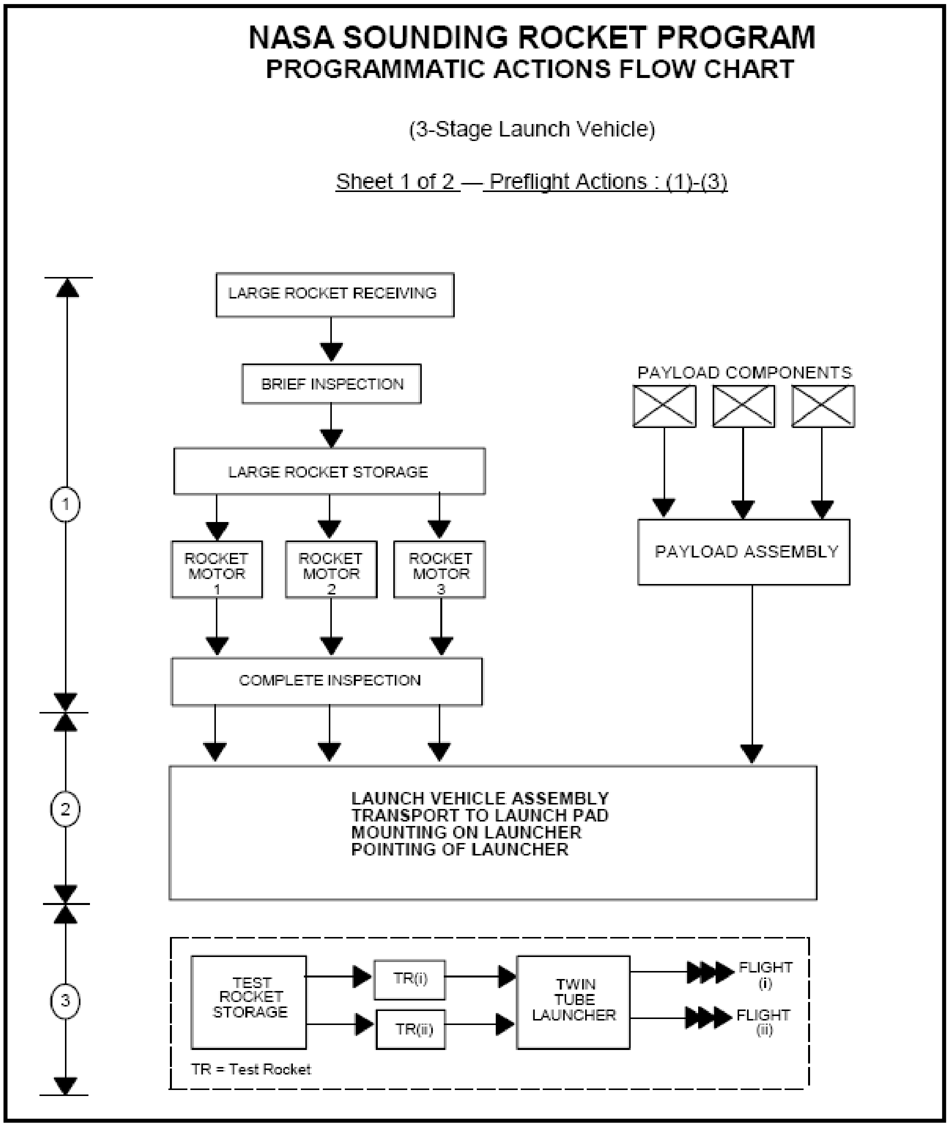


Figure 2–23. NASA Sounding Rockets Program Programmatic Actions Flow Chart, Sheet 1

Sheet 2 of Figure 2–23 shows the major components of a typical flight, followed by recovery operations and closure actions (if required). For the assumed three-stage rocket propulsion system on Sheet 2, three burns are followed by three separations.

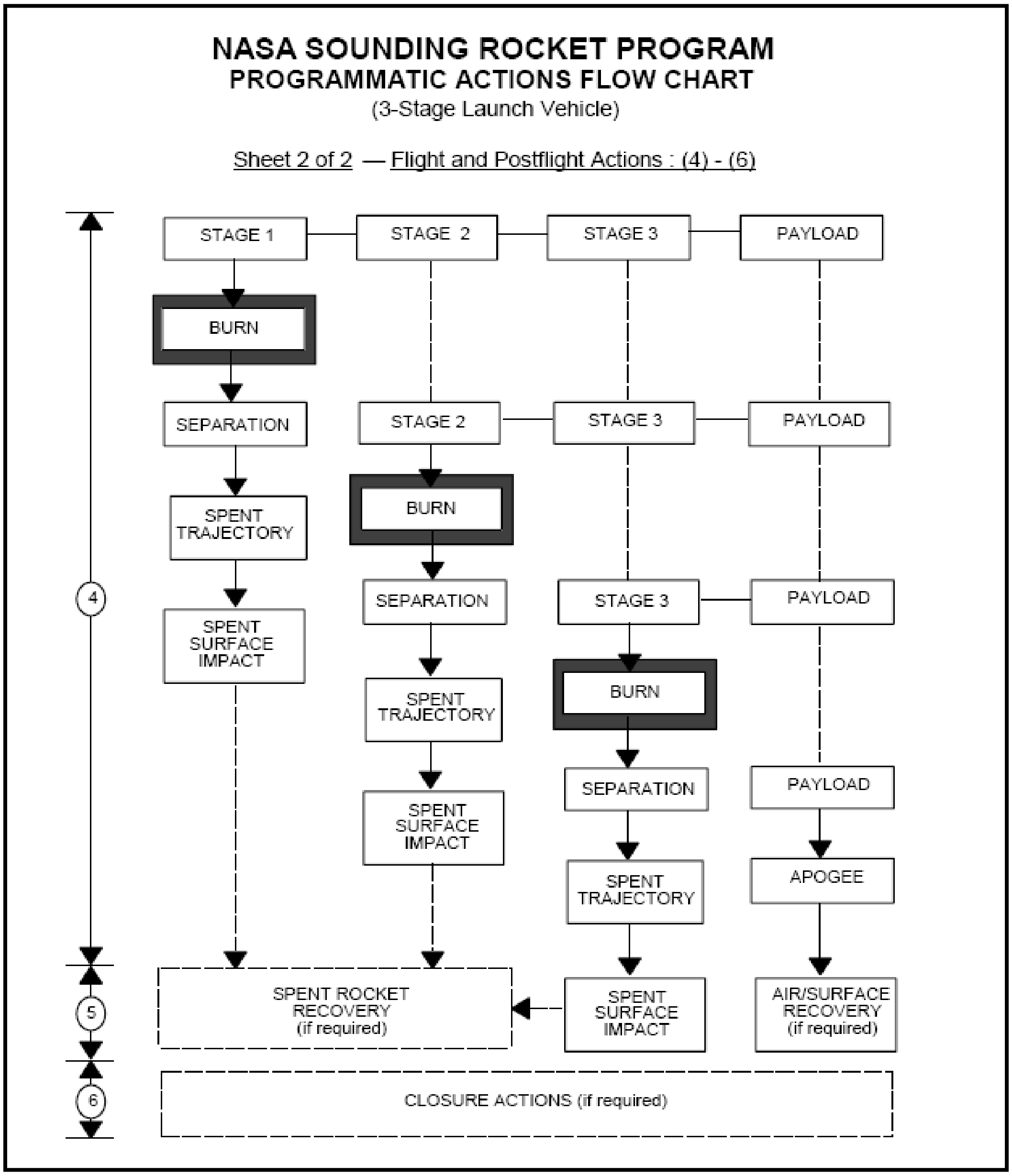


Figure 2–23. NASA Sounding Rockets Program Programmatic Actions Flow Chart, Sheet 2 (*continued*)

Ongoing Maintenance

The approximately five full-time staff from UAF conduct routine operations at PFRR. These employees maintain the physical plant, provide launch support, and provide the administrative support to obtain launch approvals to support operations. They are supported by UAF personnel and contractors on an as-needed basis to maintain the facilities and support operations and launches. The UAF Geophysical Institute also provides engineering and technical support as needed. On an annual basis, personnel from WFF travel to PFRR during the summer months to perform routine maintenance of launchers, radars, etc.

Pre-Launch

The sounding rockets are built and tested at WFF by SRP staff in the months preceding a launch. This is the same process followed by SRP for sounding rocket launches at all sites. These operations are described in the *SRP SEIS* **(NASA 2000a)**. Typically, the scientific research group will build the payload at its home facility. The payload will then be shipped to WFF, where it will undergo rigorous testing to ensure that it is compatible with the rocket and meets all NASA technical and safety requirements. Once the complete rocket system and payload are ready, they are typically shipped by truck from WFF to PFRR.

In the weeks before a launch, additional personnel arrive from the research group (typically university staff and graduate students) and from SRP at WFF for launch preparations. As a result, the personnel working at PFRR will typically increase by 5–10 from the university research group and 15–25 from WFF. Depending on the nature of the experiment, these personnel will typically spend 3 to 4 weeks in preparation for the launch.

Launch Day

On launch day, the launch team arrives at PFRR approximately 4-hours prior to the opening of the launch window to begin countdown operations. During the 4-hour countdown, range staff performs a variety of preparatory tasks, including testing radar and telemetry systems, inspecting the payloads one final time, notifying the FAA and U.S. Space Command, and analyzing weather conditions (discussed in more detail below under ***Flight Safety***). In the final minutes of the countdown, the range will then typically enter a holding pattern until both the science conditions and range safety analysis indicate that the mission is ready for launch. Typically, a 6-hour science window is allotted for each launch attempt (in addition to the 4-hour preparatory period described above). Once both safety and science criteria are met, the rocket is then launched. Generally, the science requirements are the most challenging to meet, and as such, the launch team may be required to go through the 10-hour countdown process numerous times (*i.e.*, over several days to several weeks) before the launch occurs. It is not uncommon for the team to conduct countdown operations for more than 15 nights before the appropriate scientific conditions occur for launch.

2.1.6.1 *Range Safety*

General

Ensuring employee and public safety is NASA's highest priority for NASA when conducting operations at PFRR. Each launch campaign at PFRR has an assigned team of independent safety personnel located on-site during all hazardous activities. These safety personnel are responsible for ensuring mission team compliance with the requirements of the *Range Safety Manual for Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF)* (RSM-2002B) **(NASA 2008)** as well as PFRR-specific safety criteria established by UAF. When NASA launches sounding rockets from non-NASA site, such as PFRR, the safety requirements established by NASA are used as a minimum unless requirements of the host range are more stringent, in which case the more stringent requirements apply. PFRR is a case where its safety criteria are more stringent than NASA's and are therefore applied.

The NASA Range Safety Officer (RSO), the NSROC Mission Manager, the WFF Project Manager, and the NASA Operations Safety Supervisor (OSS) share responsibility (within the limits of their jurisdiction) for the safe performance of operations associated with a mission. Within NASA, range safety responsibilities are divided into two general areas – ground safety and flight safety. Ground safety considers activities associated with pre- and post-flight hazardous operations while flight safety encompasses all activities that pertain to the flight of a vehicle after it is launched. In addition to the risk assessments and safety plans developed for sounding rockets, the same process is followed for the test rockets. The sections below provide more detail regarding each of these functions as they apply to launches at PFRR.

Ground Safety

Each mission's Ground Safety Plan identifies the hazardous systems that exist on the rocket and payload and ensures that ground-based hazardous operations are consistent with NASA safety standards. Each hazardous operation requires that an OSS oversee the process to ensure that the Ground Safety Plan is followed. Depending on the safety category during various launch operations, restrictions may be imposed on launch site personnel who are not directly participating in the procedure. Examples of typical hazardous operations overseen by an OSS at PFRR include the installation of pyrotechnic devices (*e.g.,* for separation of stages during flight) or high pressure vessels (*e.g.,* used onboard the payload for precision alignment during flight) during rocket and payload assembly. A commonly-employed ground safety practice is to establish exclusion zones (by roadblock or other audible or visual means) within which only appropriately trained and operationally-essential personnel are permitted.

Flight Safety

The primary goal of flight safety is to contain the flight of all vehicles and to avoid an impact that might endanger human life or cause damage to property. Whereas ground safety is primarily process-based, flight safety is generally quantitative in assessing risk. In flight safety, risk is defined as the probability of a vehicle or payload landing in an undesirable location.

During mission planning, a Flight Safety Risk Assessment is performed to determine if the mission can be conducted within an acceptable level of risk. Inputs into the risk assessment include the experimenter's desired flight performance (altitude, duration, azimuth, etc.), the specific type of rocket proposed, the characteristics of the payload, etc. Once details of the planned flight are known, the safety analyst then considers downrange population densities, the locations of areas to be avoided, and other constraints to then calculate mission risk values. These mission risk values are subsequently compared to the PFRR-specific criteria and weighted toward approval of the mission. If risk values are determined to be above the established criteria, modifications to the flight (*e.g.,* slightly different apogee, payload configuration) are then considered in an effort to meet both safety criteria and minimum science requirements. Once safety criteria are deemed suitable, the analyses in the risk assessment are then incorporated into a Flight Safety Plan, which is used by the launch site to establish launch day constraints (*e.g.,* launcher settings, wind limits) and specific off-limits areas, which are subsequently conveyed to regulatory agencies and the general public. Additional details regarding PFRR-specific risk criteria and provided in Chapter 3, Section 3.13.

A key component of ensuring flight safety is to understand the wind profile at the launch site, as winds will affect the flight of the rocket, especially during its early stages of flight when its velocity is low. To address this concern, NASA range safety staff performs what is known as wind weighting, which involves predicting the effect of the wind on the trajectory of a sounding rocket and, in most cases, compensating for the wind to achieve a predicted impact point.

In support of wind weighting, PFRR has a permanent wind measurement tower located immediately adjacent to the launch pads. In addition, during launch countdown, range personnel release latex meteorological balloons to obtain a characterization of the upper atmospheric winds. Three types of balloons are used: (1) a 1,200-gram high altitude balloon, (2) a 300-gram mid-altitude balloon, (3) and 100-gram "chaff" balloons. The high- and mid-altitude balloons loft a global positioning system (GPS) radiosonde, which relays meteorological information directly to PFRR (see **Figure 2–24**). The "chaff" balloons, which are typically launched every 15–30 minutes during the final hour of countdown, contain a small piece of aluminum foil (a reflective target for radar systems) and during nighttime launches, a short-burning flare which aids the radar operator in initially acquiring the balloon for tracking.

Figure 2–24. Launching a GPS Radiosonde Balloon from PFRR

All meteorological data that are collected during the launch countdown are automatically fed into the wind weighting computer system at PFRR, which provides real-time estimates of launcher settings and prediction of impact points. An iterative procedure of adjusting the launcher settings is used until the predicted impact point matches the desired nominal impact point. If all range safety criteria are met based upon this real-time calculation, the launch proceeds as planned. Otherwise, the launch may be put on hold or scrubbed for the day until suitable conditions are available.

In addition to minimizing the risk to people and property on the ground, each mission's Flight Safety Plan includes requirements to avoid the potential for affecting aircraft in the nearby area. To accomplish this, aircraft "clear zones" are established and coordinated with the FAA as described below. As an added safety measure, during launch countdown PFRR employs a surveillance radar system to monitor aircraft activity in the vicinity of the launch site. If an aircraft is identified within the proposed rocket flight corridor, its activity is tracked until it is within an area deemed safe. Until the flight zone is clear of aircraft traffic, the launch cannot occur.

Airspace and Rocket Launch Operations

Launches are permitted under annual agreement with the FAA in the form of a Letter of Agreement between FAA, the Anchorage Air Route Traffic Control Center, the Fairbanks Airport Traffic Control Tower, and UAF. FAA also furnishes a Certificate of Waiver in response to PFRR launch request applications. The waived regulations are established in Title 14 of the *Code of Federal Regulations* (CFR), Section 101.25 (a)(b)(c)(d) and (f).

The Certificate of Waiver held by UAF is subject to mandatory safety provisions, which include the establishment of flight safety areas and clear airspace zones, dissemination of launch information to the public through media outlets, and military coordination with the U.S. Department of Defense to avoid conflict with military aircraft.

Coordination between FAA, NASA, and PFRR occurs pre-flight, when a time-date launch "window" is designated. This coordination continues throughout the planning and launch period to ensure launch facility and public safety and to prevent conflict with other air traffic. The FAA issues Notices to Airmen, which contain information for pilots regarding the times and geographic extent of areas that may be affected by launch operations. Time of use for the PFRR rocket launches is sunset to sunrise, unless otherwise coordinated or permitted by FAA.

Maritime Traffic and Rocket Launch Operations

An important consideration for safely launching rockets into maritime environments is to ensure that mariners are aware of pending operations such that they can avoid planned impact areas. Prior to each launch with ocean impacting flight hardware, PFRR coordinates with the U.S. Coast Guard to issue a Notice to Mariners (NOTMAR). The NOTMAR is broadcast through various public media prior to launch operations and describes the times and locations of planned launch impacts.

2.1.6.2 *Dispersion in Impact Locations*

The term “dispersion” in this EIS means the statistical deviation of the actual impact location of a spent rocket stage from the predicted value. All sounding rocket launch vehicles lack onboard guidance systems, which are typically employed on larger rocket systems such that the vehicle will fly along a pre-programmed route, correcting its flight path along the way.

Due to slight differences in the physical properties of each rocket (*e.g.,* fin misalignment, weight variation) and the variability of atmospheric conditions, actual trajectories deviate from the predicted ones. The dispersion has downrange (short or long) and cross-range (left or right) components and is used to calculate the probability of impacting within a given distance of the nominal impact point. This distance is referenced to a standard deviation, or “sigma” value, from the mean point of impact. In the case of sounding rockets, a circular dispersion is employed; such that for each launch the probability of a stage landing within 1-sigma of its predicted impact point is approximately 40 percent; within 2-sigma, 87 percent; and within 3-sigma, 99 percent.

NASA derives two types of dispersion values for its sounding rockets. A *theoretical dispersion* is determined by varying each of the parameters that affect impact range or azimuth. Each parameter is varied by a certain amount, and then input into a calculation to determine the difference in impact points for each parameter. A *flight history dispersion* is derived by comparing the actual impact locations to the predicted impacts. This method yields reliable dispersion values if a sufficiently large number of flights for a similar payload weight and launch parameters are available.

Table 2–3 is an example of a flight history dispersion, and shows the results of a statistical analysis of hundreds of flights of all launch vehicles, over ranges of payload weights and launch angles for a given launch vehicle. The downrange and cross-range dispersion components are stated as “one-sigma” apogee percentages. Analysis of the measured data leads to a number of conclusions:

1. Dispersion is dependent on apogee, *e.g.,* dispersion is higher for a light payload with higher apogee than for a heavy payload with lower apogee (for a given launch vehicle).

2. Downrange dispersion (short or long) always exceeds cross-range dispersion (right or left).

3. Dispersion is somewhat higher as the number of rocket stages in a launch vehicle increases.

Table 2–3. Measured Dispersion of Sounding Rockets Program Final-Stage Spent Rockets, 1986–1995

Launch Vehicle[a]	Payload Weight Range (kilograms)	Quadrant Elevation or Launch Angle (degrees)	Number of Flights	Downrange Dispersion (percentage apogee)	Cross-Range Dispersion (percentage apogee)
18	42–180	73–86	12	8.9	8.5
21	160–630	78–86	15	18	12
27	240–520	82–89	23	16	14
29	93–240	76–85	6	13	11
30	36–106	80–86	10	13	8.7
31	50–408	74–86	49	11	7.9
33	65–240	70–86	11	14	7.4
34	26–67	78–85	1	15	4.9
35	70–380	76–86	18	22	22
36 (with S-19)[b]	320–540	85–87	75	2.2	2.2
36[c]	190–490	81–85	26	11	11
38	32–120	79–84	13	17	7.4
39[d]	530–701	84–85	2	14	12
40[d]	110–430	80–84	9	17	15

a. 18=Nike-Tomahawk; 21=Blank Brant VB; 27=Nike-Black Brant VB; 29=Terrier-Malemute; 30=Orion; 31=Nike-Orion; 33=Taurus-Orion; 34=Taurus-Tomahawk; 35=Black Brant X; 36=Black Brant IX; 38=Taurus-Nike-Tomahawk; 39=Black Brant XI; 40=Black Brant XII.

b. S-19=Boost Guidance System.

c. Dispersion based on rail-launched vehicles only.

d. Theoretical dispersion.

Source: Johnson 1995.

2.1.7 Landing and Recovery Operations

All metallic and other solid heavier-than-air objects that are propelled into the atmosphere by sounding rockets land back on Earth in more or less ballistic trajectories. The objects include spent rocket stages, payloads; nose cone doors (released in flight for instruments to "see" their targets); and spin weights, which were released to change rotation of a rocket stage of a launch.

2.1.7.1 *Landing Locations*

Short-Range Spent Stages

In multistage SRP launch vehicles, the first stage, or "booster," of the rocket invariably flies a very short trajectory, following a burn time of only a few seconds. The function of the "booster" is literally to get the remaining stages and the payload off the ground. In **Table 2–4**, the values of impact range (distance from launch point along surface to impact point of the spent rocket stage) of all multi-stage vehicles currently in use are 3 kilometers (1.9 miles) or less, with some as small as 0.3 kilometers (0.2 miles). Spent rocket stage impact weights are in the 300- to 800-kilogram (660- to 1,800-pound) range.

Table 2–4. Short-Range First-Stage Rocket Motor Trajectories

Launch Vehicle Number[a]	Number of Stages	Launch Rocket (First Stage)	Typical Launch Rocket Trajectory (kilometers)		Typical Impact Weight (kilograms)
			Apogee	Impact Range	
36	2	Terrier	2.3	0.2	302
41	2	Terrier	8.5	3.0	302
35	3	Terrier	1.2	0.3	302
39	3	Talos	3.0	1.5	802
40	4	Talos	2.5	1.0	802

a. 35=Black Brant X; 36=Black Brant IX; 39=Black Brant XI; 40=Black Brant XII; 41=Terrier-Improved Orion.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.

Medium-Range Spent Stages

As shown in **Table 2–5**, the spent second stage in a three-stage launch vehicle can have an impact range from 5 to 295 kilometers (3.1 to 183 miles) varying with selected payload weight and apogee. The spent stage impact weights are in the 270- to 600-kilogram (600- to 1,300-pound) range. Also shown in Table 2–5 are impact ranges for the spent 70-millimeter (0.3-inch) test rockets, which are flown to calibrate ground radar before launch; these test rockets have a short 3-kilometer (1.9-mile) impact range.

Table 2–5. Medium-Range Sounding Rockets Program Spent Second-Stage and 70-Millimeter Test Rocket Trajectories

Launch Vehicle[a]	Number of Stages	Stage Number and Name	Apogee (kilometers)	Impact Range (kilometers)	Typical Impact Weight (kilograms)
35	3	2 Black Brant	80.0	295.0	270
39	3	2 Taurus	12.5	5.0	606
40	4	2 Taurus	9.0	12.0	606
70-Millimeter Test Rocket	1	70-Millimeter Test Rocket	5.8	3.0	6.8

a. 35=Black Brant X; 39=Black Brant XI; 40=Black Brant XII.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.

Spent Final Stages

Table 2–6 tabulates the typical impact ranges and impact weights of spent final stages for currently used NASA SRP launch vehicles. With impact ranges varying from values of about 60 kilometers (37 miles) for single-stage vehicles to over 1,100 kilometers (680 miles) for the four-stage Black Brant XII, it is clear that each flight presents a specific case. The final stages are lighter than preceding stages, so that impact weights are 140 kilograms (310 pounds) or less, except for the Black Brant (270 kilograms [590 pounds]), which can be used in multiple stages.

Table 2–6. Spent Final Stage Trajectories

Launch Vehicle Number[a]	Number of Stages	Name of Final Stage	Apogee (kilometers)	Impact Range (kilometers)	Typical Impact Weight (kilograms)
21	1	Black Brant[b]	240	80	270
30	1	Orion[b]	100	60	140
36	2	Black Brant	300	290	270
41	2	Orion	180	200	140
35	3	Nihka	960	550	94
39	3	Black Brant	380	320	270
40	4	Nihka	1,500	1,200	94

a. 21=Black Brant V; 30=Orion; 35=Black Brant X; 39=Black Brant XI; 40=Black Brant XII; 41=Terrier-Improved Orion.

b. Also name of launch vehicle.

Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.

Summary of Spent Stage Locations

Table 2–7 presents the general estimated locations for spent stages from all NASA sounding rockets launched from PFRR since its inception.

Table 2–7. General Location of NASA Sounding Rocket Motor Stages

Projected Downrange Landing Distance (km)	Number of Stages	General Location of Stages
0–12	202	ADNR Poker Flat North and South Special Use Areas
12–80	50	White Mountains NRA
80–250	46	Mainly in Yukon Flats NWR
250–550	127	Arctic NWR, Native Village of Venetie Lands, ADNR lands
>550	34	Beaufort Sea/Arctic Ocean
Unknown	2	Unknown

Key: ADNR=Alaska Department of Natural Resources; km=kilometers; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Notes: Impact points for stages based on nominal ranges for individual stages on the sounding rockets and, for launches from 1997 through 2012, on the predicted impact points of each stage or where items were recovered. To convert kilometers to miles, multiply by 0.6214.

Payloads

Most payloads that are flown from PFRR are not designed with recovery systems (*i.e.*, a parachute) as there is no scientific need to re-use the instrument. Additionally, the size and weight of such a system can be prohibitive in obtaining science requirements, which are often driven by a specific apogee or flight duration. Section 2.2 of this EIS discusses recovery system considerations (and why they are not always employed) in more detail. In the absence of a recovery system, payloads follow a ballistic trajectory that is very close to the final rocket motor stage.

For payloads that are retrieved for data extraction, inspection, refurbishing, and prospective reuse, they are separated from the final rocket stage and then slowed by a deployable parachute at about a 6-kilometer (3.7-mile) altitude. As a result, the payload decelerates and floats down at a rate and in a direction determined by local wind conditions. The parachuting payload would be expected to impact the ground at speeds near 10 meters per second (33 feet per second). The payload is located by its proximity to the final-stage rocket motor and often by coordinates provided during flight by the onboard telemetry system.

2.1.7.2 *Search and Recovery Operations*

Past and Recent Efforts

Past PFRR recovery efforts have focused primarily on the payload when needed for recovery of science data. In these cases, the payload stage was equipped with a parachute to limit damage and facilitate recovery. Spent rocket stages were only recovered sporadically, or if desired for some mission-related purpose.

Of the 219 sounding rockets launched by NASA at PFRR since 1969, the payloads were recovered from approximately 50 of the sounding rockets, with 10 recovered from single-stage rockets, 37 from two-stage rockets, 2 from three-stage rockets, and 1 from a failed four-stage rocket. The majority were recovered from areas 30 to 70 kilometers (18 to 44 miles) downrange. **Table 2–8** presents a summary of the recovery locations of past NASA-launched payloads.

Table 2–8. General Location of Recovered NASA Sounding Rocket Payloads

Downrange Distance (kilometers)	Payloads Recovered	Land Parcel
0–12 km	1	ADNR Poker Flat North and South
12–80 km	20	White Mountains NRA
80–250 km	13	Yukon Flats NWR
250–550 km	16	Arctic NWR, Venetie, ADNR
550 km	0	Beaufort Sea/Arctic Ocean
Total	**50**	

Key: ADNR=Alaska Department of Natural Resources; km=kilometers; NRA=National Recreation Area; NWR=National Wildlife Refuge.

The remaining payloads and most of the rocket motors remain at unknown locations within PFRR's downrange lands. In general, the rocket stages were not tracked with radar (since such radars were generally not available) and their exact impact points are not known. All radar assets were generally used to track the payload but even that has proven difficult because of terrain and curvature of the Earth, limiting (or in many cases precluding) the ability of the radar to detect the payload on its path down to land impact. Several payloads that were intended for recovery were never found. It has been within the last few years that a greater level of effort has been made to also find and recover rocket motors in addition to the payloads.

As such, the past four flights from PFRR (during the 2011 and 2012 launch seasons) have included search and recovery of rocket stages and payloads as a standard component of each mission. All missions were flown on two-stage rockets (Black Brant IXs), with the second stage motor successfully located and removed for the first mission, and the payloads located and removed for the latter two missions in 2011. For the 2012 flight, the second stage motor was located shortly after launch and is planned for removal in summer 2012. For all four flights, the first stage rocket motors landed within the Alaska Department of Natural Resources (ADNR) lands just north of the launch site.

Challenges in Location and Recovery

Due to the heightened awareness regarding the location of items in downrange lands, NASA has employed both electronic and visually based tactics to improve its ability to find items soon after launch. However, this process has proven to be very difficult as discussed below.

Figures 2–25 to **2–30** are photographs that illustrate the difficulty in finding payloads and stages. In Figure 2–25, no colors were visible from the fixed-wing aircraft during spotting operations; what was seen was a small disturbance in the snow. Even painting the motors has not proven effective. When viewed from a fixed-wing aircraft at 150 to 305 meters (500 to 1,000 feet) above ground level, the stages are often hidden within the landscape features. Only in some cases, such as when an item lands on fresh snow, are the motors visible. Similarly, even the payloads with brightly colored parachutes are often not readily visible to search aircraft if they come down in rugged terrain (see Figure 2–26). Unless very good GPS locations are known, finding stages has been compared to finding a "needle in a haystack." With the current technology, the predicted area where a stage might land will typically have a radius of 10 percent of the downrange distance and encompass tens to hundreds of square miles.

Figure 2–25. View of the February 2012 Powell Mission Second-Stage Impact from a Search Aircraft

Figure 2–26. View of the February 2011 Bailey Mission Payload Parachute from a Search Aircraft

Figure 2–27. Zoomed-in View of the Bailey Mission Payload Parachute from a Search Aircraft

Figure 2–28. Picture of January 2011 Green Mission Black Brant Rocket Motor from Hovering Helicopter

Figure 2–29. Photos Provided by Members of the Public During the Preliminary 2010 EA Scoping Process of Sounding Rocket Remains near Wind River

Figure 2–30. View of Stages as Found in Downrange Lands

In general, it is not practical to add locating beacons and other electronic devices to the spent rocket stages to facilitate finding them. The only possible location for installing a device on a rocket motor is the forward head cap, which in most cases is the leading end that impacts the ground surface, severely damaging its contents (see Figure 2–30).

The most recent experience with payloads equipped with Iridium satellites/GPS transponders has been good. However, it took five unsuccessful flights to determine that the system can only be activated once the returning payload is suspended under a deployed parachute. When activated, the GPS receiver simply cannot endure the dynamic forces encountered during the ascent of a sounding rocket.

In addition to the technical challenges of locating the main payload, a growing number of missions (currently more than 30 percent) employ smaller sub-payloads and “free-fliers” that are ejected during flight. Payloads configured in this manner are often referred to as “mother/daughter,” with the “mother” as the larger payload and the “daughter” as the smaller of the two. Since PFRR only has one precision-tracking radar, only the “mother” payload is actively tracked to impact or loss of signal, whichever comes first. The daughter portion of the payload would likely impact in the same general area as the mother when the separation of the two bodies is done only by compressed springs. Hence the absolute separation distance will generally be on the order of hundreds of meters but not much more. However, even within this relatively small search radius, the presence of sharp topographic relief or dense vegetation can make locating the smaller items difficult. Section 2.4.8 of this EIS provides more detailed information regarding NASA's ability to electronically track stages and payloads during flight and subsequent impact.

Operational Constraints

Many aspects of PFRR's recovery operations are governed by the USFWS requirements stipulated in the compatibility determinations for rocket payload impact and recovery in Arctic and Yukon Flats NWRs **(USFWS 2005a, 2005b)** as well as Special Use Permits issued by USFWS and BLM **(USDOI 2011a; USFWS 2011a, 2011b)**. Full permit documentation is included in Appendix C; however, a high-level summary of the requirements that PFRR and NASA must meet to ensure minimal effects on downrange lands. At any point, permits may be canceled or revised by the land manager due to high fire danger, flooding, unusual resource problems, or other significant problems or emergencies.

Notification of Activity

- PFRR is required to notify each land manager before beginning and upon completing activities allowed by the permit.

- All rocket launches must be well publicized in advance to forewarn travelers and residents of the area involved. A minimum of 2 weeks' notice of rocket launch dates and impact zones must be provided in writing to the refuge manager.

- Three days prior to launch, PFRR must post notices of planned rocket launches over BLM administered lands at the major trail heads on the Steese and Elliott Highways.

- PFRR must maintain a viable rocket component recovery program to track, locate, and remove rocket debris annually. The land manager must be informed of locations of impact sites, unrecovered rockets and/or payloads, and any potential hazards that may be created.

Avoidance of Sensitive Times and Areas

- Rocket or debris impacts within the USFWS lands are prohibited from May 1 through September 30 to avoid periods of high public use unless specifically requested within 45 days before the intended launch. Exception requests to USFWS are required to include a complete project description, a statement affirming that the proposed dates are essential, the alternatives considered an analysis of the increased risk incurred, and a justification for this risk.

- PFRR cannot undertake launches with a planned impact site within the Mollie Beattie Wilderness Area within Arctic NWR.

- On USFWS lands, helicopter activity cannot occur within one-half mile of active raptor nest sites during the period from May 1 through August 15.

- On BLM lands, any overland moves shall be completed within the confines of area's current off highway vehicles (OHV) regulations or be limited to winter between December 1 and April 15 and with a minimum of 0.15 meters (6 inches) of snow cover and 0.30 meters (12 inches) of frost depth are present.

Protection of Natural and Cultural Resources

- The use of off-road vehicles (except snow machines) on USFWS lands is prohibited.

- When flying over USFWS lands, all aircraft are recommended to maintain a minimum altitude of 610 meters (2,000 feet) above ground level, except during takeoff and landing, and when safety considerations require a lower altitude. Low-level slinging of gear from site to site is prohibited.

- Large-scale clearing of vegetation for aircraft landing and takeoff is prohibited. Only minor clearing of brush and other minor obstructions is permitted.

- Any excavation or disturbance during recovery must be filled.

- Fuel caches are allowed only in designated areas on the USFWS lands, and must be approved by the NWR manager before they are established. Storage must meet the standards of the USFWS, Alaska Region, Fuel Storage Policy.

- PFRR must ensure that its operations do not interfere with or harass NWR visitors or impede access to any site.

- PFRR operations cannot interfere with subsistence activities of rural users or restrict the access of subsistence users.

- The removal or disturbance of historical, recent, ethnological, or archaeological artifacts is prohibited.

- PFRR must ensure that a transponder or other radio location aid is incorporated with each payload to facilitate tracking and recovery after launch.

- PFRR must clean equipment used to recover rocket debris to prevent the spread of invasive and noxious weeds and plant species at recovery sites.

Collectively, the restrictions and conditions imposed by USFWS and BLM provide the operational restraints on the program and dictate the practices that must be followed.

Typical Search Operations

Post-Launch Search

After a typical nighttime launch, a search operation will normally commence the following day if weather conditions permit and staff and plane are available. If scientific conditions require launch late in the evening or early in the morning, a recovery operation may not be initiated at first light because work-hour limitations may prohibit fielding the necessary staff. Also, since the team often waits on precise scientific conditions for launch, the aircraft provider may not be available immediately after launch. The impact range of the launch also factors into this decision of exactly when to initiate a recovery flyover. For a three-stage or four-stage rocket, the third stage may land several hundred kilometers downrange necessitating a flight of several hours. Thus factoring in limited daylight, work-hour limitations, and the potential for bad weather, it may not always be practical to initiate a flyover search the very next day, but the initial flyover search would commence as soon as practicable.

The flyover search would typically commence at first light from the Fairbanks airport. Since these launches typically occur in winter, hours of sunlight are short and good visibility is required both for flight safety and to visually find the payload.

Choice of search aircraft might vary with the circumstances, with choices ranging from a small, 2–4 passenger plane that would provide slower flight speeds for enhanced chances of seeing the payload but longer flight times and lower capacity for observers to larger planes, such as the Short Skyvan 7, which would permit more observers and faster transit times, but higher ground speeds during search operations. Both types of planes have been used by PFRR and NASA staff in the past and that practice would likely continue.

Searches for Previously Identified Stages

Since learning of public concern regarding the presence of flight hardware in downrange lands in 2010, NASA has implemented an interim “clean range policy,” a component of which is the payment of a monetary reward to members of the public who report items to PFRR.

The public has been asked to provide GPS coordinates and a photograph of each object found to the extent practicable. Once reported, PFRR provides verification through visual search with fixed-wing aircraft. Some of the objects may also be inspected on the ground prior to a decision on whether recovery is possible. Flights to confirm location of identified objects have not occurred during winter due to the safety concerns of winter flying and the difficulty of identifying objects covered with snow. Rather, flights have occurred during spring before ice breakup when snow is still on the ground but vegetation is limited, and during summer. **Table 2–9** provides an inventory of those items reported to PFRR since the implementation of the interim “clean range policy.”

Long-term plans for adopting a formal Flight Hardware Recovery and Rewards Program are discussed in more detail in Section 2.3.4 and are a key consideration in the alternatives evaluated in detail in this EIS.

Table 2–9. Reported Sounding Rocket Hardware Since Interim "Clean Range Policy"

Date Reported	Type of Item	Reporter	Land Parcel	General Location	Date Recovered
February 2010	Motor	Private Citizen	Native Village of Venetie	11 kilometers northeast of Tsyooktuihuun Lake	Pending[a]
June 2011	Motor	Private Citizen	Yukon Flats NWR	10 kilometers northwest of Twelve Mile Lake	June 2011
	Motor	Private Citizens (Reported Twice)	Arctic NWR	Wind River	July 2011
	TBD	Private Citizen	State of AK (west of White Mountains NRA)	East of Bear Creek	Pending[a]
	TBD	Private Citizen	White Mountains NRA	West of Beaver Creek	Pending[a]
July 2011	Motor	Private Citizen	Arctic NWR	Wind River	July 2011
August 2011	Motor	Private Citizen and Commercial Air Operator (Reported Twice)	Arctic NWR	North Fork East Fork Chandalar River	August 2012
	Motor	Private Citizen	Arctic NWR	Junjik River, northwest side of Timber Lake	August 2012
	Motor	Private Citizen	Arctic NWR	Marsh Fork Canning River	August 2012
September 2011	Payload Item	Commercial Guide	Arctic NWR	Sheenjek River	2002[b]
	Motor	Private Citizen	Arctic NWR	South of Wind River	August 2012
	Motor	Commercial Air Operator	Arctic NWR	South of Portage Lake	August 2012
October 2011	Motor	Commercial Air Operator	Arctic NWR	West of White Snow Mountain	August 2012
	Motor	Resource Agency Employee/Commercial Air Operator (Reported Twice)	Yukon Flats NWR	29-Mile Ridge	July 2012
February 2012	Motor	Private Citizen	White Mountains NRA	Lime Peak	July 2012

Table 2–9. Reported Sounding Rocket Hardware Since Interim "Clean Range Policy" *(continued*)

Date Reported	Type of Item	Reporter	Land Parcel	General Location	Date Recovered
August 2012	Payload	Commercial Air Operator	State of AK (west of Venetie Lands)	11 kilometers northeast of Brown Grass Lake	August 2012
	Motor	PFRR Employee[c]	Arctic NWR	Near North Fork East Fork Chandalar River	August 2012
	Nosecone	PFRR Employee[c]	Arctic NWR		August 2012
	Payload	PFRR Employee[c]	Arctic NWR		August 2012
	Motor	Private Citizen	Native Village of Venetie	Near Christian River	September 2012
	Motor	Private Citizen	White Mountains NRA	Near Ophir Creek	September 2012

a. Initial reconnaissance flights did not identify reported item.
b. Item was removed from downrange lands prior to its September 2011 report.
c. Item was located while conducting search and recovery for other reported items.
Note: Does not include those reported that did not include coordinates or pictures or items removed from "new" (e.g., since 2010) launches that were not reported by the public. To convert kilometers to miles, multiply by 0.6214.
Key: NRA=National Recreation Area; NWR=National Wildlife Refuge.

Typical Recovery Operations

To best ensure personnel safety and ease of recovery, PFRR would perform recovery operations primarily during non-winter months (June through September). Experience in recent years has shown that the optimum time to execute a recovery is either in early spring or late fall, as the spring season would provide milder weather at a time before spring/summer foliage appears, and the fall timeframe would provide a period between when foliage has fallen and the onset of harsh winter conditions.

Some payloads or stages may be recovered immediately (*i.e.,* winter months) for safety reasons. An example could be a rocket motor that failed to ignite or a payload containing small pyrotechnic devices or high pressure gases that did not function properly. NASA would not want to leave any object on the ground that would pose a risk to anyone who might encounter it, and accordingly would make all reasonable efforts to ensure that its items are not a hazard to the public or the environment.

Items to be recovered would typically land on state, tribal, BLM, or USFWS land and would require permission from the landholder prior to recovery. The process for recovery could vary depending on the specific requirements of the landholder. Recovery operations within Yukon Flats and Arctic NWRs would be constrained by the specific requirements of the PFRR permits with USFWS, as summarized under *Operational Constraints* above.

Most of the stages and payloads are far enough from access points that the only practical means of recovery is by dropping recovery personnel on the ground from helicopters, attaching slings to the payload, and lifting the stage with the helicopter and transferring it to a central recovery operations area. From the central recovery area, the items would either be flown back to the Fairbanks area via fixed-wing aircraft or would be trucked over the road (*e.g.*, down the Dalton Highway). For those areas immediately adjacent to PFRR (sites from the White Mountains south), it is likely that the recovered item would be flown directly back rather than waiting for a fixed-wing flight back.

Helicopters based in Fairbanks or nearby would likely be tasked for the recovery. Potential helicopters include a Robinson R-44 (three passenger), Acestar, Bell HB-206B (Jet Ranger), and Hughes 500. Helicopters are typically available in the summer in the region to service the oil industry and fire management agencies. The helicopter would be selected to match the proposed recovery mission with consideration of stage/payload size, cost, and availability. The helicopter would ferry a small team to the landing site as close as safe and practical to the stage or payload.

The recovery team would ensure that the stage or payload was safe prior to commencing work on the item. The safety plans developed prior to the recovery effort would identify any potential hazardous materials that might be remaining on the stage or payload and establish procedures to ensure that the recovery operation could be conducted safely. Pre-recovery evaluation of telemetry data relayed to PFRR during flight would provide valuable information regarding potential hazards to the recovery team; however, careful inspection of all flight hardware would be required prior to beginning the removal or disassembly process.

The recovery team would use simple means to recover the stage. For some stages lying horizontally on the ground, this might be simply attaching a sling and bagging any small pieces, and calling for the helicopter to lift the stage and carry it to a recovery operations area. See **Figures 2–31** and **2–32** for photos of recovery.

Figure 2–31. Return of the April 2011 Brodell Mission Payload to PFRR

Figure 2–32. View of the February 2011 Bailey Mission Stage Recovery

For stages in more complicated configurations, such as partially buried in the soil, more manual labor might be required to free the stage. Typical lightweight tools such as a shovel, pick axe, crow bar, and high-lift jack, might be employed to dig up the stage (see **Figure 2–33**). In all cases, the recovery team would use the minimum tool necessary to remove the item based on landowner policy. Prior to helicopter liftoff, some mechanical disassembly also may be required, such as removal of fins to stabilize items for transport. This is the technique that has historically been used for the over 50 payloads that have been recovered to date.

Figure 2–33. Typical Hand Tools Employed for Hardware Removal

It is anticipated that some portions of a deeply buried stage may not be recoverable with hand tools. For example, some stages have been found more than halfway buried and could require use of heavy equipment for extraction (see **Figure 2–34**). A helicopter would not be able to pull it out, nor would there be sufficient manpower (using hand-carried tools) to perform a complete extraction. It is expected that the cost (both fiscal and environmental) of bringing in heavy equipment to do the extraction in this case would not be worth the benefit of extraction in most cases.

Figure 2–34. Example of Substantially Embedded Rocket Motor

Before an item is identified for recovery, the safety and risk involved with recovery, as well as the monetary cost of recovering an object, would be reviewed. If it is deemed too risky for personnel to recover a located object as it may endanger their lives, clearly the benefit of recovery would not be worth the potential cost, and recovery would not be executed. This EIS addresses the environmental impact of leaving such objects in place. On the monetary side, the cost of executing a recovery operation is also considered in that there would be limited funds available for recovery operations. As a component of its annual operating expenses at PFRR, NASA now allocates a reasonable budget to enable the recovery of stages and payloads that have been located (both new and old).

NASA and PFRR are very interested in leveraging as many existing resources to support recovery operations as practicable. As such, in the summer of 2011, a team of BLM smoke jumpers used a rocket motor recovery operation as a training exercise during a period of very low fire activity. They parachuted into an area with two stages. Each stage was cut up into smaller pieces with a motorized saw and backpacked to an assembly area 3.2 kilometers (2 miles) from one stage and 12 kilometers (8 miles) from another stage. The fire crew was picked up by a fixed-wing aircraft. The pieces of the recovered stages were picked up later by another fixed-wing aircraft. This technique worked in this case because trained smoke jumpers were available and the stages were close enough to a location that an aircraft, in this case fixed-wing, could recover the crew and stages. It is anticipated; however, that most of the future stages would be recovered by helicopter.

2.2 SELECTION OF REASONABLE ALTERNATIVES

This section of the EIS summarizes the selection process that the NASA SRP employed to identify reasonable alternatives for detailed evaluation. For an alternative to be deemed "reasonable," it must meet NASA's purpose and need (defined in Chapter 1, Sections 1.2 and 1.3), and satisfy the SRP-defined screening criteria.

From an organization perspective, this screening approach employs a "top-down" approach, meaning that NASA first considered entirely different launch sites from PFRR, followed by PFRR-specific options. The PFRR-specific options are divided into two general focus areas:

1. Options for future launch and recovery; and
2. Varied approaches for addressing the spent rocket stages and payloads that remain downrange as a result of previous NASA SRP launches at PFRR.

Those options that were carried forward for detailed analysis are then described in Section 2.3; those alternatives dismissed from further consideration (and the reasoning for doing so) are presented in Section 2.4.

2.2.1 Siting Alternatives

NASA has maintained an active sounding rocket launch program at PFRR since 1969, and as PFRR is the United States' only permanent high-latitude launch site capable of safely conducting flights along northerly trajectories, it is NASA's preference to maintain this capability into the future.

However, in response to concerns raised during public scoping for this EIS, NASA considered several other sounding rocket launch sites that might meet some or all of the requirements that have been identified for performing high-latitude and auroral science. The other high-latitude sites considered include the Kodiak Launch Complex (KLC) in Alaska; the Fort Churchill Rocket Range near Churchill, Manitoba, Canada; and launch sites in Norway and Sweden. The potential use of these sites as a reasonable alternative to PFRR is evaluated in detail in Appendix B; this section provides a summary.

The site selection process identified three criteria for evaluation of reasonableness of the alternative:

- Science
- Safety
- Practicality

Domestic Launch Sites

The majority of U.S. launch sites are in mid- or equatorial latitudes; therefore they cannot reasonably enable the study of the geophysical phenomena (*i.e.,* aurora) afforded by a northern latitude launch site. KLC is the only other permanent high-latitude site and is located on Kodiak Island, Alaska. To ensure public safety, KLC does not fly northerly trajectories, a prime scientific requirement for most experiments that study the aurora.

Foreign Launch Sites

The now inactive Fort Churchill Rocket Range, Canada, could in principle meet some of the science needs due to its geographic location, but could not reasonably provide launch site infrastructure or the ground-based observation stations (due to Hudson Bay) necessary for the scientific research, nor would it provide equivalent northerly launch azimuths afforded by PFRR due to safety concerns. The practical details and costs associated with either the re-establishment of a "new" range for long-term use or repeatedly transporting mobile launch equipment to a site with limited or no options for downrange observation would make this site impractical for those future missions that would otherwise be conducted at PFRR.

Other active launch sites in Norway and Sweden are practical and are used for some NASA SRP missions, but also do not provide the land-based downrange observation capabilities needed for PFRR-type science objectives. In the case of Sweden, the launch range is simply not large enough to safely fly the longer range rockets (*e.g.*, Black Brant-class) that have become the most commonly-used vehicles for the science conducted at PFRR. As such, these sites also cannot accommodate the science missions needed to fully meet NASA's purpose and need.

In summary, based on this assessment, NASA concluded that each active launch site provides a specific scientific niche that is leveraged according to each researcher's needs. To that end, all launch sites are needed. However, PFRR's scientific niche, which is fully described in Chapter 1, Section 1.1.5, renders it the only site that fully meets the purpose and need identified for this EIS. Therefore, this EIS only addresses alternatives for continuing NASA's SRP mission at PFRR.

2.2.2 Future Launch and Recovery Options at PFRR

Scoping comments identified a concern by members of the public that NASA was leaving the remains of its sounding rocket launches (*e.g.*, spent rocket motors or stages) in downrange lands and therefore not being good stewards of the environment. This concern was especially voiced by those who wanted to experience the wilderness of Alaska and did not expect to find parts of rockets while on hikes or trips in remote areas of northeast Alaska.

Accordingly, NASA is evaluating how future launches could be conducted in a manner that reduces the potential environmental impacts associated with launch and recovery efforts. The environmental impacts of NASA SRP launches were previously addressed in the *SRP SEIS* **(NASA 2000a)**. In the *SRP SEIS*, NASA found that actual direct environmental impacts on flora, fauna, water resources, etc. had been and were expected to continue to be minimal. The focus of the considerations in this EIS is, therefore, whether NASA could, or should, consider alternative launch and/or recovery strategies that could reduce the likelihood that spent rocket stages and payloads would remain in the field, would avoid impacts in "sensitive" areas, and whether newly expended rocket stages that do not need to be recovered for scientific purposes could or should be recovered.

When discussed in this section, "sensitive areas" are defined as the designated Wild and Scenic Rivers and Wilderness areas within the PFRR launch corridor. These rivers include the Ivishak, Sheenjek, and Wind Rivers in Arctic NWR and Beaver Creek in the White Mountains NRA and Yukon Flats NWR. The only designated Wilderness area within the PFRR launch corridor is

Mollie Beattie within Arctic NWR; however, within Yukon Flats NWR there is a recommended Wilderness area along its southern boundary with the White Mountains NRA.

2.2.2.1 *Future Launch and Recovery Option 1: Continue with Past Practices, No Change*

This option would continue to launch consistent with past practices and would permit future launches to be conducted much as in the past. NASA SRP would continue to launch sounding rockets from PFRR. The decision to launch at PFRR would be selected based on the requirements of the scientific goals, technical needs, costs, and other programmatic considerations. NASA would continue to avoid planning an impact in the Mollie Beattie Wilderness Area within Arctic NWR.

NASA SRP activities at PFRR would continue in their present form at the current level of effort. Under this future launch and recovery option, no significant efforts would be made to recover spent stages, and payloads would be recovered as dictated by the scientists.

2.2.2.2 *Future Launch and Recovery Option 2: Enhanced Efforts to Locate and Recover Newly Expended Stages and Payloads with Environmentally Sensitive Cleanup*

Under this option, NASA would continue launches at PFRR as in the recent past with enhanced efforts to locate and recover newly expended stages and payloads. NASA would work with downrange landowners and resource agencies to develop a screening and recovery plan that would allow for reasoned decisionmaking to support search and recovery of new payloads and spent stages. NASA would attempt to locate all land-impacting, newly launched stages and payloads, and if found would recover those that can be environmentally reasonable, if doing so can be done safely without endangering the public or recovery personnel. A primary component of this option is NASA's establishment of a recovery budget for each operating year at PFRR, which is described in greater detail with Section 2.3.4 below.

2.2.2.3 *Future Launch and Recovery Option 3: Restriction of Trajectories and Impact Locations with Environmentally Sensitive Cleanup*

Under this option, NASA would continue launches at PFRR as in the recent past with enhanced efforts to locate and recover newly expended stages and payloads. This option is the same as Future Launch and Recovery Option 2, except trajectories of future PFRR missions would be restricted to reduce the potential for payloads and stages landing in areas identified as environmentally sensitive, such as designated Wilderness Areas and Wild and Scenic Rivers.

2.2.2.4 *Future Launch and Recovery Option 4: Enhanced Efforts to Locate and Recover Newly Expended Stages and Payloads with Maximum Cleanup*

Future Launch and Recovery Option 4 is similar to Future Launch and Recovery Option 2 except that NASA would recover newly expended stages and payloads to the extent such recovery operations can be done safely and within available budget. In contrast to Option 2, NASA would make every effort to fully recover newly expended stages and payloads versus leaving some in place.

Under Future Launch and Recovery Option 4, NASA would implement a policy that follows the mantra of "Leave No Trace Behind." Removing any outward, visible signs of flight hardware from downrange lands would be the top priority. Under this option, NASA would attempt to clean up all newly expended stages that are found, even if it resulted in some longer-term negative environmental impacts related to the cleanup (*e.g.*, larger-scale clearing of trees and brush for helicopter landing, more intrusive excavation).

As with Option 2, Option 4 would entail the establishment of a recovery budget; however, the percentage required of the available budget would be larger due to the potential for more resource-intensive extraction efforts in the downrange lands.

2.2.2.5 *Future Launch and Recovery Option 5: Restriction of Trajectories and Impact Locations with Maximum Cleanup*

Future Launch and Recovery Option 5 is similar to Future Launch and Recovery Option 3 except that NASA would recover all newly expended stages and payloads that are found to the extent such recovery operations can be done safely and within available funding as described under Future Launch and Recovery Option 4.

2.2.3 Options for Recovery of Existing Flight Hardware

NASA identified three cleanup options for the recovery of existing items that remain in downrange lands from past launches from PFRR. These existing hardware recovery options are similar to and parallel the options identified for recovery of newly expended stages and payloads.

2.2.3.1 *Existing Hardware Recovery Option 1: Continue with Past Practices, No Change*

Under this option, NASA would continue its past practice of only recovering spent stages and payloads if mandated by scientific or other programmatic needs.

2.2.3.2 *Existing Hardware Recovery Option 2: Environmentally Sensitive Cleanup*

Under Existing Hardware Recovery Option 2, NASA SRP would ensure that its efforts to recover spent stages and payloads from past launches are conducted both safely and environmentally responsibly. Spent stages and payloads would be recovered if practical and under the condition that the environmental impacts of recovery would not outweigh the environmental impacts of leaving them in the field. NASA would:

- Develop an environmental screening and recovery plan in consultation with downrange landowners and resource agencies that allows for reasoned decisionmaking to support search and recovery of existing stages and payloads.

- Refine the catalog of existing stages and payloads and develop search strategies, including rewards for finding and reporting sites of spent stages and payloads.

- Establish an annual recovery budget to fund activities related to identifying and removing items from past missions.

NASA expects that a portion of the existing spent stages and payloads would be left in place under this option because some items are likely are located in areas where it would be unsafe to attempt recovery operations or are in locations where full removal would cause more damage than partial or no recovery.

2.2.3.3 *Existing Hardware Recovery Option 3: Maximum Cleanup*

Under Existing Hardware Recovery Option 3, NASA would develop a recovery plan (similar to that under Existing Hardware Recovery Option 2) to provide the framework within which search and recovery would be conducted. The key difference is that under this existing hardware recovery option, NASA would implement a policy that follows the mantra of "Leave No Trace Behind." Under this existing hardware recovery option, NASA would attempt to fully clean up all identified stages and payloads from past missions to the extent allowable by safety and budget considerations, even if the recovery effort did result in some longer-term environmental impacts. NASA would work to minimize those impacts, but would be willing to accept some long-term effects in support of the goal of leaving behind no obvious trace of its operations (*i.e.*, visible rocket hardware) within the PFRR flight corridor.

The largest percentage of the annual budget dedicated to recovery of existing stages would be necessary under this option.

2.3 Alternatives Evaluated in this Environmental Impact Statement

Based on consideration of the criteria developed for site selection, discussed in Section 2.2.1; potential future launch and recovery options for future SRP flights at PFRR, discussed in Section 2.2.2; and potential existing hardware recovery options for existing stages at PFRR, discussed in Section 2.2.3, NASA has identified five alternatives as potentially satisfying some or all of the objectives identified in the purpose and need for consideration in this EIS. Other alternatives were also considered and are described in Section 2.4, but were eliminated from further discussion in this *PFRR EIS* because none were found that could reasonably meet the purpose and need of the NASA SRP.

To avoid redundancy, the details common to all alternatives are solely discussed below in Section 2.3.1. Under each specific alternative, only substantive differences are presented.

2.3.1 Details Common to All Alternatives

NASA Action

Under all five alternatives, NASA would continue to fund UAF's PFRR and conduct scientific investigations using sounding rockets as described in Section 2.1.2.1. Missions would be selected using the formal solicitation, evaluation, and award process. Once the science Principal Investigator proposes a mission, the science goals and technical and management needs, costs, and risks of the proposed mission would be evaluated by NASA and compared to competing proposals and budgets. Both the science goals and logistical considerations would dictate which launch facility is most practical. For some types of high-latitude science, PFRR offers unique scientific capabilities, and would thereby be utilized as appropriate.

NASA forecasts that an average of about four launches per year would be conducted at PFRR, but could range up to eight launches per year. This launch rate is typical of past years, but, because of the very nature of scientific research and discovery, it is not possible to predict accurately what future needs might be. New discoveries or scientific needs might require more or fewer launches to accomplish NASA's scientific goals.

Similarly, past scientific research has mandated that most launches be conducted during the winter months (defined for the purposes of this EIS as October through April), with most of the launches occurring at night or in darkness. While this is the expected mode of future operations, new scientific needs might raise the desirability of other launch periods. If such needs were to arise, additional analysis of the range safety requirements, as well as potential mitigation factors to reduce environmental impacts, would be required.

BLM and USFWS Actions

Under all five alternatives, BLM and USFWS would continue to review UAF-submitted permit applications and decide whether the proposed activities allow for the issuance of permit authorizations, which would allow PFRR and NASA to continue to impact rocket motors and payloads on Federal lands. Authorizations by BLM and USFWS, if granted, would be issued to the UAF on NASA's behalf.

2.3.2 No Action Alternative – Continue NASA SRP at PFRR in its Present Form and at the Current Level of Effort

NASA Action

Under this alternative, no significant efforts would be taken to recover future spent stages unless desired for programmatic reasons, and future payloads would be recovered as planned by the scientists. Thus, recovery efforts and impacts would primarily be focused on retrieval activities associated with recovery of parachuted payloads.

This alternative is consistent with *Future Launch and Recovery Option 1* and *Existing Hardware Recovery Option 1*.

BLM and USFWS Actions

Under the No Action Alternative, BLM and USFWS issued permits would allow NASA and PFRR to determine which payloads or stages would require recovery.

2.3.3 Alternative 1 – Continue NASA SRP Activities and Flights at PFRR within Existing Flight Zones, with Environmental Screening for Recovery of New and Existing NASA Stages and Payloads (Environmentally Responsible Search and Recovery Alternative)

NASA Action

Under Alternative 1, NASA and UAF would employ enhanced efforts to track and locate new and existing spent stages and payloads within the PFRR flight corridor. Attempts would be made to recover all newly expended stages and payloads predicted to land on Federal, state, or private lands. Spent stages and payloads that are located would be recovered if it is determined that the recovery operation can be performed safely while causing minimal environmental damage. At the discretion of the landowners, materials could be left in the field or removed, consistent with the Recovery Plan, which is discussed below in Section 2.3.4.

For past SRP operations at PFRR, most spent rocket stages have not been recovered. Some payloads were designed with parachutes to facilitate recovery of the scientific data. Others were assumed to be spent and thus were not designed to facilitate recovery; these remain unrecovered for the most part. Consistent with the philosophy that would be employed for new rocket motors and payloads, hardware that is located from past operations would be recovered if it could be done safely and in an environmentally responsible manner.

If and when downrange impact sites are located, PFRR would document the impact site and determine what recovery operations may be feasible, the timeframe of the recovery, and the expected environmental impacts of the recovery. These findings would be presented to the landowner or Federal administrator to determine if and how recovery would be handled.

This is consistent with *Future Launch and Recovery Option 2* and *Existing Hardware Recovery Option 2*.

BLM and USFWS Actions

Under Alternative 1, BLM and USFWS would issue permits allowing PFRR to impact rocket payloads and spent rocket stages on Federal lands within the PFRR flight corridor; however, a post-launch search and subsequent recovery would be required to the extent that such a recovery can be done safely and with minimal environmental damage.

Landowners could authorize located materials to be left in the field under certain circumstances, which would be consistent with the PFRR Recovery Plan (described below); on which both BLM and USFWS would be participants in developing.

2.3.4 Proposed Draft Recovery Plan

Locating all of the vehicle and payload components flown on any given mission presents a number of technical and logistical challenges that make it virtually impossible to locate and recover every object. The distances involved, the areas traversed, and the relative size of the payloads/vehicles make finding an object downrange challenging.

Therefore, to most effectively leverage available resources, the Draft PFRR Recovery Plan (see Appendix E) would employ a three-tiered approach. This section below provides a summary of NASA's programmatic commitments to implementing the program and the procedures that would be followed to address flight hardware from both future missions and those conducted in the past.

Tier 1: Continual Improvement of Location Aides

The first tier involves a programmatic commitment to continually improving NASA's ability to locate all major sections of flight hardware, which include each rocket motor and the main payload assembly. Below is a discussion of available technologies, their advantages and limitations, and opportunities for future improvement.

Radar/Global Positioning System - Radar and GPS are the primary methods employed to track the location of both rocket stage and payload components. In many cases, the payloads flown at PFRR contain both radar beacons and GPS receivers. However, the main payload section is the only object whose location is actively tracked by radar and/or GPS. This is most often due to scientific requirements to know the precise altitude, range, and time of the payload during the data collection period and not to determine its final impact location. Estimation of the final impact location is further complicated by the fact that both radar and telemetry systems (which provide the means to transfer the GPS data) lose their transmission signals (known as Loss of Signal) while the object is still in the air. This is due to both physical masking associated with the White Mountains immediately north of the range and the curvature of the Earth, when coupled with the range of the rocket. Loss of Signal often occurs at several thousand feet to tens of thousands of feet, depending on the range of the rocket.

Most recently, GPS systems that do not require a line-of-sight telemetry link to the launch site have been tested on several sounding rocket flights. One system, which relies on the Iridium constellation of earth-orbiting satellites, survived flight and provided reliable coordinates for the location of the Bailey (36.256) and Brodell (36.278) payloads in the 2011 launch season. It should be noted that this system had been flown several times before that with no success; however, the continual testing uncovered a technical detail (see Section 2.1.7.2) that once resolved has provided very promising results.

Implementation of a system to provide location data for rocket motors; however, has proven to be more challenging due to the harsher flight environment. A system that relies on a commercially available GPS was flown on the 2011 Brodell mission; however, it did not survive flight. Given this challenge, NASA is currently working with providers of location devices designed specifically for high-impact environments to determine if such a system may be technically feasible for sounding rockets.

Analytical Predictions – Predictions of the planned impact locations of each object associated with a rocket flight are routinely made to facilitate safety analysis and risk planning. These planned impact locations are based on nominal flight parameters and “no wind” environmental conditions. Due to the fact that NASA’s sounding rocket vehicles are unguided, relatively large dispersions are associated with the impact point of each object, which adds a degree of complexity to locating the item.

However, the NASA Safety Office and the SRP have recently implemented enhanced techniques for determining the impact location of rocket motor stages and payload components launched at PFRR. Once the vehicle is no longer thrusting (all its fuel has been consumed), the objects follow a simple ballistic trajectory. Flight safety analysts can combine datasets from multiple tracking sources (*e.g.*, telemetry and radar) to determine the “state vector” (which encompasses position, velocity, direction, and momentum) and then combine that information with atmospheric wind measurements taken during the launch process. This provides the most accurate prediction of the impact site, as it is based on the actual flight path of the rocket, and it can be performed for all objects released as part of the experiment (nose cone, sub-payloads, main payload, etc.). Using current computer-aided analytical tools, it can be accomplished within several hours of the actual launch, thus expediting the search phase of the recovery operations. The methodology has been employed on recent PFRR-launched missions and has proven helpful in refining location estimates for items that are not tracked by radar or have onboard telemetry equipment (*e.g.,* rocket motors). NASA would continue to refine this process that has become a standard post-launch procedure for PFRR launches.

Non-Traditional Location Aides – Other electronic location aides such as homing devices and pingers have been used in the past to enhance recovery; however, none of these technologies have been successful in providing position data due to high accelerations and the harsh flight environment. In addition to electronic devices, NASA has recently employed visual aides to assist in the location of rocket motors. For example, on the April 2011 Brodell mission, both ejectable strobe lights and search and recovery streamers were added to the head cap of the second stage motor (see **Figure 2–35**); however, neither proved to be successful as the motor was not located.

Figure 2–35. Strobe and Streamer Combination Used on April 2011 Brodell Mission

The application of fluorescent colored markings on the rocket motors has recently been employed at PFRR. Although this technique would only prove effective if the motor landed on its side (and was not covered by snow), it is possible that these markings could assist in the location of stages during the non-winter months when snow would be absent. NASA and PFRR would continue to evaluate the use of non-traditional location aides to improve the visibility of items to search crews.

Tier 2: Search for all Newly Launched Stages and Payloads; Recover if Practicable

Under this tier of the Recovery Plan, NASA and PFRR would commit to conducting post-launch searches for the on-land (*i.e.,* not in the Beaufort Sea or Arctic Ocean) flight hardware components (*i.e.,* stages and main payload) for all future missions. If flight hardware is successfully located within downrange lands, a decision-making process (involving the respective landowner) would then follow to determine the necessity and practicality of performing a recovery operation as outlined below.

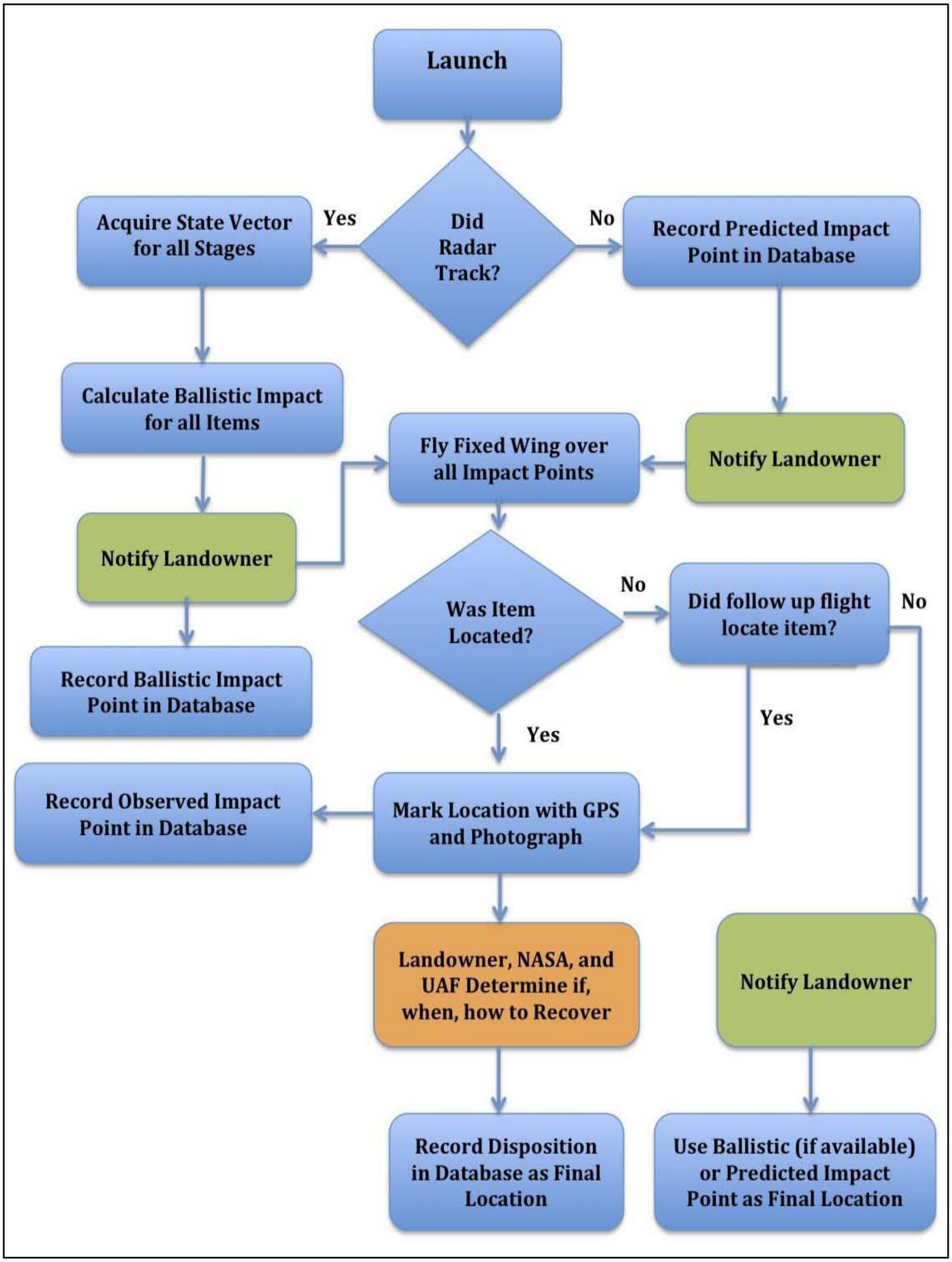
It is important to note that the focus of the recovery efforts under this tier is the downrange lands located north of the ADNR Poker Flat North and South Special Use property just across the Steese Highway from the PFRR launch site. Given the land use within the ADNR property (discussed in more detail in Chapter 3, Section 3.8); there is heightened sensitivity to land-disturbing activities, particularly those associated with a recovery operation. Therefore, regular (*i.e.*, annual) recovery activities would likely not take place within this property. NASA and PFRR intend to remove easily accessible spent rocket motors on an occasional basis in coordination with the property's managing organization; however, it is expected that these efforts would less frequent (*e.g.*, every several years) and would likely result in a greater proportion of those left in place (as compared to other properties within the flight corridor) if is determined that a measurable amount of land disturbance would be required.

Location Procedures – **Figure 2–36** outlines the process by which the recovery post-launch location of items would be executed. Taking all previous considerations into account, the most effective way to predict the location of the major launch-related items is to use the actual burnout conditions (state vector) and calculate a ballistic impact using state-of-the-art trajectory programs. This process would involve immediate collection of the last available position data (either GPS or radar) and use of these data in trajectory simulation programs to calculate impact points for all stages and major payload pieces (as described above under *Analytical Predictions*).

Once the flight's analyst has provided these points, they would be entered into the PFRR recovery database, and arrangements would be made to fly an aircraft over these points. The goal would be to do this as soon as possible after launch (within 24 hours if practicable), such that snow would not cover the items prior to the search. Due to launch times driven by scientific conditions, coordination with aircraft providers, limited daylight in winter months, and the impact range of some objects, it may not always be practical to meet the 24-hour goal. In some instances, it may be elected to wait until the snow has melted to begin the search. A good example of this might be if it happens to snow a large amount immediately after launch. This would make spotting an object from an aircraft nearly impossible such that it would be prudent to wait until a later time. Regardless, coordination with the landowner would be part of the decision process. The landowner or Federal administrator (Yukon Flats NWR, Arctic NWR, and/or BLM) would be offered a seat on the recovery aircraft to assist in spotting any objects.

If the objects are not located immediately after launch as prescribed above, at least one additional flight would be conducted as soon as practical after snowmelt to see if the object can be located. Similar procedures would be followed to effect recovery and would be recorded in the database.

Records of all attempts at locating objects would be maintained as part of the PFRR recovery database. Data to be recorded should include the type of aircraft, provider, and name of participating personnel, date and time of flight, duration, and landings should they be made. Any objects located would be photographed, their GPS coordinates logged, and any adjacent identifying landmarks noted that may assist in recovery planning/operations. This would provide a record of recovery hours logged as part of NASA's recovery operations.



Note: Green shapes indicate landowner consultation required; orange indicate landowner approval required before proceeding.

Figure 2–36. Post-Launch Search Process Flow Chart

Recovery Procedures **–** Once an object has been located, enough information needs to be collected about the impact site such that an objective decision can be made whether to attempt a recovery. Recovering large pieces of hardware in remote wooded areas or mountainous terrain presents a number of technical and logistical challenges. Lack of roads, the type of terrain, type of vegetation, safety of personnel, and sensitivity of the impact site are all factors in determining whether a recovery operation should be executed. In addition, the size and condition of the object, expected disturbance of the environment, and cost-benefit would factor into this decision process. If recovery is to be attempted, the team also needs enough information to make an efficient and effective recovery plan. If there is insufficient information to make these determinations, further investigation of the impact site would be conducted to collect relevant information to aid in the decisionmaking process.

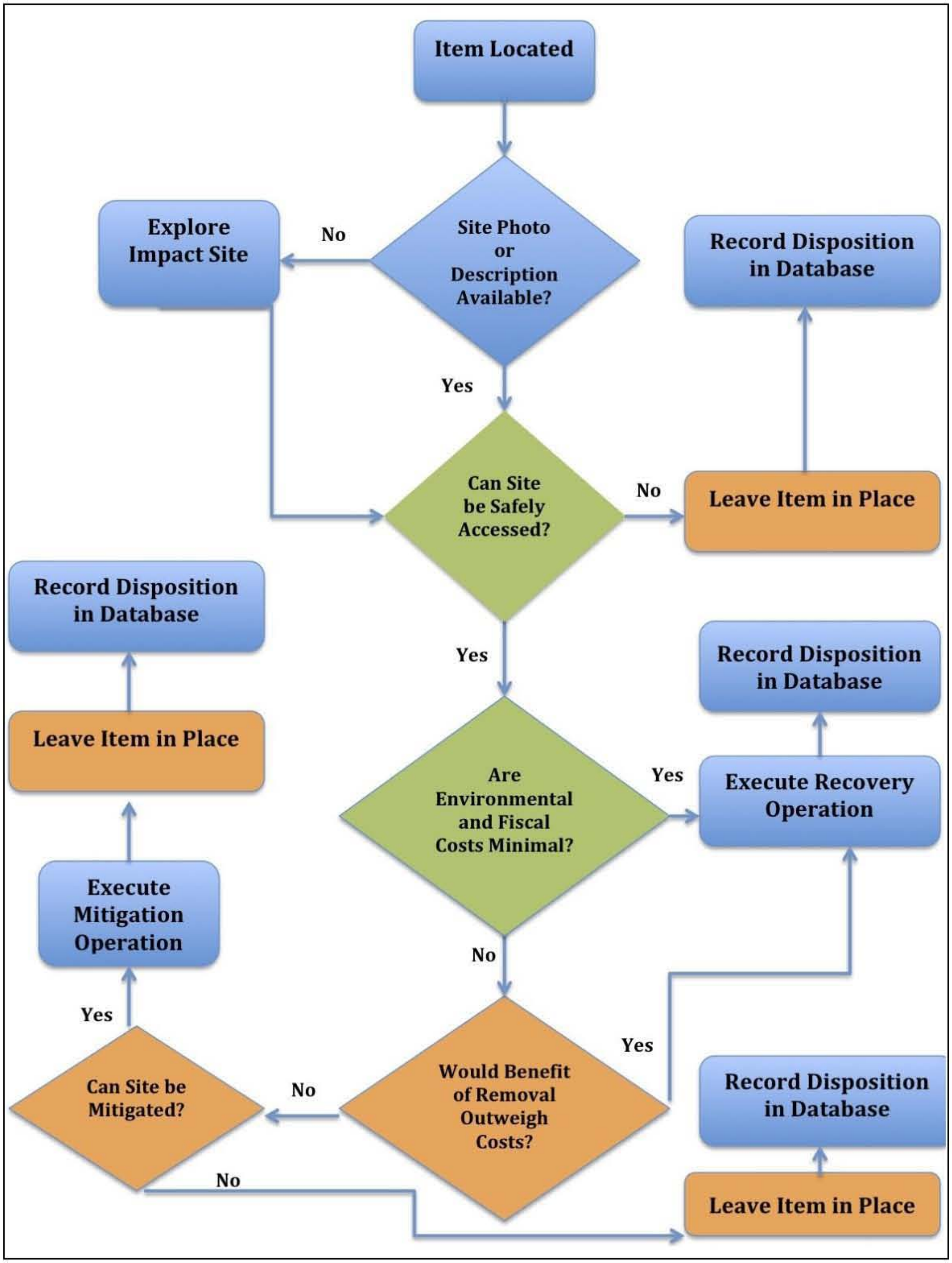
The following flow chart summarizes the decisionmaking process (see **Figure 2–37**), throughout which the landowner would be involved.

The first major decision point is to determine whether it is safe for personnel to access the impact site. If the natural location of the impact site is deemed too hazardous for personnel to enter/operate (*e.g.,* side of a cliff), the object would be left in place and recorded in the database.

The second major decision point is to evaluate both the environmental and cost impacts of executing the recovery operation. If there is minimal environmental impact of retrieving an object and reasonable cost associated with doing so, recovery would be performed as soon as practicable. If this is not immediately obvious, a cost-benefit analysis considering both environmental impact and cost shall be conducted. Both are equally relevant considerations that must be evaluated before the decision is made to execute a recovery operation. For example, if it were necessary to employ heavy earth-moving equipment (*e.g.,* backhoe, bulldozer) to fully recover an object at a remote site; this may very well not be worth the effort because of its likely environmental impacts as well as its cost. Additionally, the expenditure of exorbitant amounts of funding on recovering a single stage or payload in many instances could prevent other items from being removed from the flight corridor.

The third major decision point is whether the impact site can be mitigated in the event the decision is made to forgo a full recovery operation. Impact site mitigation may entail burial of the object, partial recovery, or other activity deemed appropriate to mitigate its effects. Again, these decisions would be situation-specific and made in consultation with the respective landowner.

Recovery Budget **–** Each Fiscal Year, a minimum of $250,000 of the PFRR annual budget would be allocated for recovery activities. Actual expenditures would vary from year to year, and would be dictated primarily by launch activity and the amount of hardware reported by users of downrange lands (discussed in more detail below). These funds are expected to have a 2-year expiration, meaning that if not spent within 2 years, the funds are required to be returned to the U.S. Treasury; therefore, if not spent, the funds would effectively be lost by the NASA SRP. If circumstances warranted, available recovery funding from one previous fiscal year could be utilized to augment the $250,000 annual budget.



Note: Green shapes indicate landowner consultation required; orange indicate landowner approval required before proceeding.

Figure 2–37. Recovery Process Flow Diagram

Prioritization of Recovery Funds **–** As the PFRR annual recovery budget would be essentially fixed from year to year, and to maximize available funds, NASA would assign priority to recovery from downrange lands. Highest priority would be given to designated Wilderness areas followed by Wild and Scenic River Corridors. Although no rockets would intentionally be flown into these areas, the possibility of landing within such an area cannot be discounted. After these areas are addressed, priority would be dictated by which identified recovery would remove the most flight hardware for the least cost. In performing recovery, it would be NASA's intent to maximize economies of scale or "out of the box" recovery opportunities, such as the employment of government firefighting or natural resources related personnel who may be in the vicinity of an identified flight hardware item. Accordingly, these opportunities would be given elevated priority once recovery of items within the most sensitive lands was completed.

Tier 3: Leverage Available Outside Resources

NASA acknowledges that even with continual improvement of location aides and the establishment of a recovery program and associated budget; it is likely that all hardware would not be located through its post-flight efforts alone. Additionally, although it is NASA's intent to locate and recover flight hardware from past missions; conducting reconnaissance flights over large areas of land in the absence of accurate hardware locations would not be the most efficient means of locating these items. However, NASA is aware of the numerous commercial and private aircraft that overfly the downrange lands, particularly during the non-winter months. Also, the large amount of downrange land that is either hunted or fished on a regular basis, particularly by hundreds of subsistence users, lends itself to a partnership opportunity for locating flight hardware. PFRR would employ Alaska Native Village residents in search efforts to the extent practicable. For certain missions that have expected hardware landing locations within either Tribal lands or within areas historically used by a particular Village, PFRR would consult with the respective Village Council, regardless of land ownership.

Rewards Program – NASA and PFRR would institute a formal and comprehensive Rewards Program to assist in locating and recovering rocket and payload hardware. A public awareness campaign would be mounted to inform villages, hunters, and others, as appropriate, of the Rewards Program. The public would be instructed to contact PFRR, provide GPS coordinates and a photograph (or verbal description if not possible) of the suspected item, and refrain from disturbing or touching the flight hardware due to the potential hazards. Assuming that the report appears credible, PFRR would then commission a flight to confirm the item's location and its disposition. If the item were confirmed to be a component of a PFRR launched sounding rocket, PFRR would then pay the reward to the person who originally reported the item. The reward would vary depending on what the item is; the highest reward would be paid for spent rocket motors, and all other flight hardware (*e.g.*, payload, nosecone, doors) would have the same lesser reward value. To avoid the potential for paying multiple rewards for the same object before its ultimate recovery, the reported item's location would be recorded in the PFRR-managed database for future reference. Funding for rewards would be taken from the PFRR *Recovery Budget* discussed above.

When possible, each major component on future missions, including each vehicle stage and main payload, would have contact information affixed to it for positive identification. Depending on mission requirements, this could be a plate attached with words inscribed, stamped, or stenciled in paint. Once positively identified, NASA and PFRR would consult with the respective landowner to finalize recovery plans. For items deemed irrecoverable, PFRR staff would be responsible for removing "reward" markings such that it would not be reported multiple times.

Rewards Eligibility **–** It is important to note that the Rewards Program would apply to hardware from all past PFRR launches, regardless of sponsoring organization. Also, consistent with the goal of focusing recovery efforts on lands north of the ADNR Poker Flat North and South parcels, the Rewards Program would not apply to the ADNR property. Furthermore, resource agency personnel who locate items when performing their official duties as public employees would not be eligible for payment.

2.3.5 Alternative 2 – Continue NASA SRP Activities and Flights at PFRR within Existing Flight Zones with Maximum Removal of Spent Stages and Payloads (Maximum Cleanup Search and Recovery Alternative)

NASA Action

Alternative 2 is the same as Alternative 1, except maximum practicable effort would be exerted to fully recover newly expended and existing spent stages from PFRR if it is determined that they can be recovered safely, even if the efforts result in longer-term environmental impacts, to obtain the benefit of downrange lands having less rocket hardware. The key difference under this alternative compared to Alternative 1 is that NASA would also implement a policy that follows the mantra of "Leave No Trace Behind." This policy would be implemented for both the recovery of new payloads and stages and the recovery of existing spent stages, payloads, and other hardware to the extent practicable.

NASA recognizes that this cleanup effort might require the use of heavy equipment in remote areas, resulting in more disruption, but it is possible that the long-term benefits of removing outwardly visible hardware could outweigh those associated with a more intensive recovery effort. In addition, this alternative would require more flight time in the search phase locating flight hardware. Examples of when recovery would be attempted under this alternative when otherwise it would be abandoned in place under Alternative 1 would be highly situation specific, but could include situations when recovery of deeply buried items would create ground scars from larger excavations, accessing areas of saturated soils ruts would form ruts (see **Figure 2–38**), or when a more substantial removal of trees and shrubs would be necessary to allow the landing/staging of recovery equipment. NASA would work to minimize those impacts to the extent practicable, but would be willing to accept those disruptions and impacts in support of the long-term goal of a having the least obvious signs of its operations within the PFRR launch corridor.

Under this alternative, NASA expects the most flight hardware to be recovered over the long-term; however, with a minimum of $250,000 annual recovery budget, it is possible that the expenditure of a larger amount of funding on a single recovery operation could reduce the possibility of recovering other hardware that is reported later in a given year.

This alternative is consistent with *Future Launch and Recovery Option 4* and *Existing Hardware Recovery Option 3.*

Figure 2–38. Example of a Deeply Buried Rocket Motor in a Wetland/Bog Area

BLM and USFWS Actions

Similar to Alternative 1, BLM and USFWS would issue permits to UAF which would stipulate that all future flights with probable impacts on their lands must include search and recovery efforts as long as they can be done safely. The key difference between this alternative and Alternative 1 is that, consistent with NASA's "leave no trace behind" philosophy described above, the land management agencies would be willing to permit greater long-term environmental disturbances related to recovery for the benefit of having fewer outward signs of flight hardware within the PFRR launch corridor.

2.3.6 Alternative 3 – Continue NASA SRP Activities and Flights at PFRR with Restricted Trajectories to Reduce Impacts on Designated Environmentally Sensitive Areas, (Environmentally Responsible Search and Recovery Alternative with Restricted Trajectories)

NASA Action

Alternative 3 is the same as Alternative 1, except trajectories of future sounding rocket missions would be restricted such that planned impacts would not be permitted within designated Wild and Scenic River corridors. The restriction would be an extension of the existing prohibition on having planned impacts within Mollie Beattie Wilderness Area and would become a program requirement that must be met during mission planning. The restriction on planned impacts within Mollie Beattie Wilderness Area would remain in effect.

Although this alternative would not eliminate the possibility of an item landing within a designated Wild and Scenic River or Wilderness area, it would reduce the probability of landing within those areas for future missions that would have otherwise "aimed" to land within the area. The actual reduction in probability of impact would be mission-specific, and would be dictated by multiple factors, including the size of the item's dispersion and the distance from the resource that the trajectory was shifted.

Based upon an evaluation of planned impact points for the past 10 years of launches at PFRR, it is not expected that this alternative would have substantial effects on NASA's ability to continue the flights of its most frequently specified sounding rockets (Terrier-Improved Orion, Black Brant class). However, it is possible that some future missions could require trajectory modification to ensure that the impact area is not within a designated river corridor.

This alternative is consistent with *Future Launch and Recovery Option 3* and *Existing Hardware Recovery Option 2.*

BLM and USFWS Actions

Under this alternative, BLM and USFWS actions would be the same as under Alternative 2. The key difference is that the agencies would issue permits to UAF such that launches could only be conducted if planned impacts are outside of Wild and Scenic River corridors. Or, the land management agencies could continue to issue permits without this restriction and rely on NASA's voluntary compliance to ensure that it is met for all future launches.

2.3.7 Alternative 4 – Continue NASA SRP Activities and Flights at PFRR with Restricted Trajectories to Reduce Impacts on Designated Environmentally Sensitive Areas, (Maximum Cleanup Search and Recovery Alternative with Restricted Trajectories)

NASA Action

Alternative 4 would be the same as Alternative 2, except that like Alternative 3, NASA would (either voluntarily or as required by permit) restrict the flight trajectories of future PFRR missions such that planned impacts would not be located within Wild and Scenic River corridors.

This alternative is consistent with *Future Launch and Recovery Option 5* and *Existing Hardware Recovery Option 3.*

BLM and USFWS Actions

Under this alternative, BLM and USFWS actions would be the same as under Alternative 2. The key difference is that the agencies would issue permits to UAF such that launches could only be conducted if planned impacts are outside of Wild and Scenic River corridors. Or, the land management agencies could continue to issue permits without this restriction and rely on NASA's voluntary compliance to ensure that it is met for all future launches.

2.4 ALTERNATIVES CONSIDERED BUT DISMISSED FROM DETAILED STUDY

Based on the site selection process discussed in Section 2.3.1, several alternative launch sites for the types of sounding rocket missions flown at PFRR were eliminated from further consideration because they did not fully meet NASA's purpose and need for preparing this EIS. These included sites in other parts of the United States and sites in Norway and Sweden. In addition, several programmatic and PFRR-specific alternatives were considered but dismissed because they also did not meet the purpose and need; these alternatives are discussed below.

2.4.1 Cease NASA SRP Activities and Flights at PFRR

Regarding new NASA SRP missions under this proposed alternative, the following would occur:

- NASA would discontinue SRP use of PFRR.
- Scientific research afforded by PFRR would not be performed.
- Funding of UAF and PFRR would only continue for recovery activities associated with past missions.

Under this alternative, NASA SRP would discontinue funding UAF to manage PFRR and would not conduct any further sounding rocket launches at PFRR. SRP launches would continue at other U.S. and foreign sites to support scientific needs. However, the scientific objectives identified by NASA in Chapter 1 of this EIS, including the investigation of auroral phenomena, would not be fulfilled. It is expected that without NASA SRP support, the level of activity at PFRR would decrease substantially. While possible that other government, commercial, or academic institutions may utilize PFRR, it is unknown to what extent. Since implementing this alternative would not meet NASA's purpose and need, this proposed alternative was dismissed from further consideration in this EIS.

2.4.2 Launch from Other Sites in the United States

Current U.S. public and privately controlled launch ranges include the following:

- Wallops Flight Facility, Wallops Island, Virginia
- Cape Canaveral Air Force Station, Florida
- Vandenberg Air Force Base, California
- Reagan Ballistic Missile Test Site, Kwajalein Atoll, Marshall Islands
- White Sands Missile Range, New Mexico
- Kodiak Launch Complex, Kodiak Island Borough, Alaska

Of these sites, the KLC is the only facility at a latitude potentially compatible with the needs of the typical science missions supported by PFRR related to auroral and high-latitude science. However, the KLC is designed to launch in the southeast-to-southwest direction, over open water. The approved launch trajectories would prohibit reaching the northern launch azimuths necessary to obtain data that support the types of scientific missions conducted at PFRR. Additionally, PFRR is already equipped with the requisite infrastructure for performing sounding rocket launches, while the KLC is not.

All of the other sites available in the United States or, in the case of the Reagan Ballistic Missile Test Site, the Marshall Islands, are too far south to allow for the study of auroral science. In summary, launching from other ranges in the United States would not meet NASA's purpose and need; thus, this proposed alternative was dismissed from further consideration in this EIS.

2.4.3 Conduct a Subset of Launches at Other High-Latitude Launch Sites, Thereby Avoiding Federally Managed Lands

Under this proposed alternative, limited NASA SRP activities at PFRR would continue, but NASA would conduct a subset of launches at other high-latitude launch sites, thereby avoiding federally managed lands. Currently, only three ranges are available that could meet some of the scientific needs: the Esrange Space Center near Kiruna, Sweden; the Andøya Rocket Range in Andøya, Norway; and the SvalRak Range in Ny-Ålesund, Svalbard (an archipelago in the northernmost part of Norway).

Over the past decades, NASA SRP has used these European ranges for some of its missions. From 1998 through 2010, NASA SRP launched 91 missions from PFRR; 18 from Andøya, Norway; 12 from Kiruna, Sweden; and 4 from Ney-Ålesund, Svalbard.

As indicated in the screening process in Section 2.3 and Appendix B, under this proposed alternative, each existing launch site provides a unique niche; accordingly, many of the science goals that would be met with launches from PFRR could not be fully met with launches from these other sites. Since implementing this alternative would not allow NASA's purpose and need to be met, this proposed alternative was dismissed from further consideration in this EIS.

2.4.4 Use Alternative Platforms for Research and Technology Validation

Alternative platforms to sounding rockets consist of other ways in which NASA and its sponsored scientists can make observations and accomplish the aims of its Science Exploration Program. These may involve making observations from the following locations or means:

- The ground
- Aircraft
- Scientific balloons
- Satellites orbiting Earth
- Deep space probes

A full description of these options and their benefits and limitations are discussed in Section 2.1.1 of the 2000 *SRP SEIS*; this section is intended to provide a summary.

Sounding rockets provide the only means for in situ measurements at altitudes between the maximum altitude of balloons (approximately 50 kilometers [30 miles]) and the minimum altitudes for Earth-orbiting satellites (approximately 160 kilometers [100 miles]). In the area of space plasma physics, which is typically studied by launches from PFRR and other high-latitude launch sites, all proposed alternative platforms discussed above are unsuitable or produce data of lower quality. In other disciplines, observations from the ground, aircraft, and balloons result in reduced quality of the scientific data collected in some instances and a total inability to conduct experiments in other instances. The use of the other larger rockets, satellites, and space probes could meet the program objectives in some instances; however, high-technology vehicles are not always available to low-cost science projects, such as those enabled by NASA SRP.

Furthermore, the propulsion systems used to lift other rockets, satellites, and space probes are considerably larger and more complex than those required by NASA SRP. The use of deep space probes could facilitate some program objectives, but the costs associated with and relative small number of deep space probe launches preclude them as a reasonable alternative.

Aside from cost, the scientific community requires multiple research platforms with which to work as each provides its own niche, whether temporal, spatial, or technical. This is evidenced by the growing number of research programs that employ multiple platforms, including on-the-ground assets, orbiting satellites, and sounding rockets, as the data collected by one can either complement or validate the others. In summary, the use of alternative platforms in place of sounding rockets would not meet NASA's purpose and need; thus, this proposed alternative was dismissed from further consideration in this EIS.

2.4.5 Installation of a Recovery System on All Future Missions

This alternative would entail the installation of a recovery system on each future payload flown from PFRR. Currently, NASA only employs recovery systems on those missions for which the recovery of the payload is required by the researcher for either data retrieval or subsequent reuse. Although it could improve the location of the main payload section from downrange lands, it would not contribute to a better positional accuracy of spent stages or smaller secondary payloads or "free-fliers" that are be ejected during flight. The realized benefit would be from both having the option of installing a GPS-based Iridium-type tracking system (which has been shown to only function properly when coupled with a parachuted reentry) and the enhanced visual cues provided by the brightly colored parachute. However, the installation of such a system would have several key considerations that would render it unfeasible for the majority of missions conducted at PFRR. A summary of those considerations is presented below.

Loss of Science – When planning a sounding rocket mission, a primary consideration of the design team is how to meet the minimum requirements specified by the science team. Typically, researchers studying plasma physics phenomena at PFRR will specify a minimum apogee and flight time above a certain apogee as minimum requirements to obtain the necessary data. The additional 45 kilograms (100 pounds) of mass associated with the recovery system would have the effect of reducing the available time for science collection and in many instances minimum success criteria could not be met. Two examples are provided below to illustrate the effect of the extra mass on two recently flown missions. These missions were selected because they depict the most commonly used vehicles at PFRR that would have a payload impact on downrange lands. While the Black Brant XII would be more commonly flown than the Black Brant IX, its payload impacts several hundred kilometers offshore in the Beaufort Sea/Arctic Ocean where recovery would not be feasible.

The first example, **Figure 2–39**, depicts the minimum altitude specified by the researchers for the February 2012 Powell mission flown aboard a Black Brant IX. Also depicted on the figure are two trajectories, the first of which is the flight that was designed to satisfy the minimum scientific requirements and did not contain a recovery system; the second "dashed line" trajectory is a simulation of how the additional recovery system mass would lower the maximum altitude that the rocket could obtain and therefore not meet the minimum requirements.

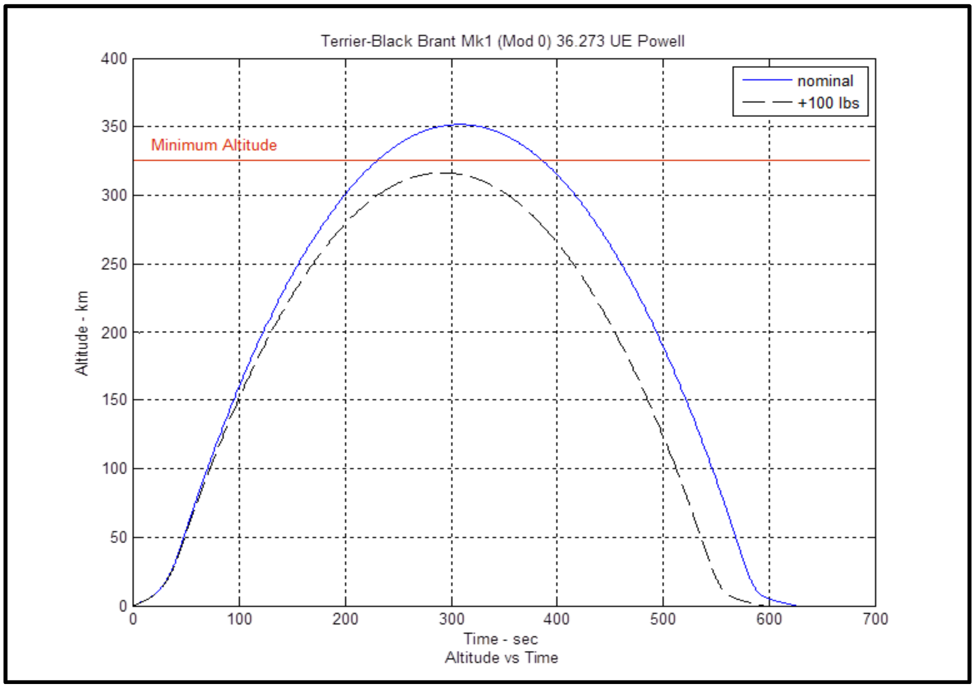


Figure 2–39. Effects of a Recovery System on a Recent Black Brant IX Trajectory

The second set of trajectories depicted in **Figure 2–40** below is from a recent flight of two Terrier-Improved Orions. Similar to the example of the Black Brant IX, the minimum science requirements could not be met with the recovery system's mass onboard.

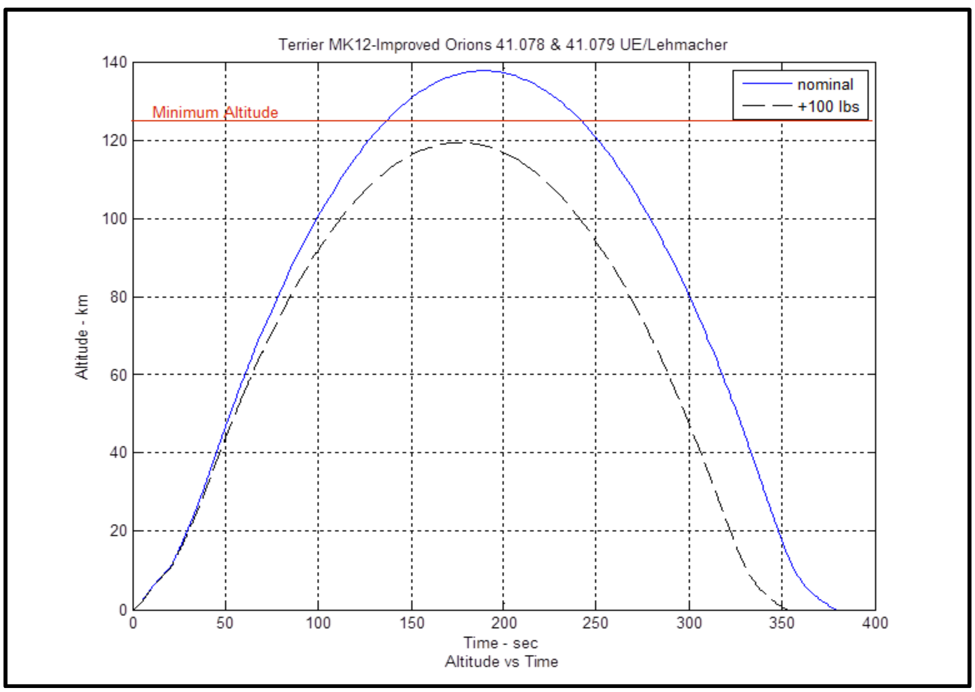


Figure 2–40. Effects of a Recovery System on a Recent Terrier-Improved Orion Trajectory

In addition to limiting the ability to meet the specified altitude and/or flight time, many of the payloads flown at PFRR employ sensors on both the forward and aft ends of the payload assembly, further complicating the installation of a recovery system, as it would prevent the successful deployment of the instruments if it were attached at either end. Therefore, in cases when the addition of a recovery system would preclude NASA's ability to obtain its requisite science, it would therefore not meet its purpose and need for conducting sounding rocket-based research at PFRR, and would not be a viable alternative for consideration in this EIS.

It is possible that on future missions, the minimum science requirements could be met despite the inclusion of the additional mass for the recovery system. However, in such cases, additional design considerations must be considered as summarized below:

***Launch Vehicle Dynamics* –** The installation of a typical recovery system would add not only weight, but also length and a necessary change in the rocket's nosecone. Missions with scientific objectives such as those at PFRR employ a straight tapered nosecone to ensure that the vehicle provides a stable flight to fly straight and true. Careful consideration of location of the payload parts is required to ensure that this stability is achieved. The addition of too much weight affecting the payload's center of gravity can have a negative effect on the vehicle flight path.

In summary, due to the inherent technical implications of incorporating a recovery system on every mission flown from PFRR, NASA eliminated the alternative from further consideration in this EIS. However, for those future missions having primary objectives that can only be met with the addition of a recovery system (and can therefore accept either a smaller payload and/or lesser vehicle performance); NASA would continue to incorporate them into vehicle design consistent with past and current practice.

2.4.6 Adoption of Numerical Risk Criteria for Specially Designated Environmental Features

Due to concerns raised during scoping regarding potential impacts on high value lands, particularly Wilderness areas and Wild and Scenic Rivers, NASA evaluated the possibility of adopting numerical risk criteria for reducing the probability of impacting those individual features. Similar to the process currently employed for range safety, future rocket trajectories would be restricted or would require modification if a probability of impacting within a particular area exceeded the established criteria.

Two numerical criteria were evaluated. The first criterion, 1 chance in 1,000 (or 1×10^{-3}), was evaluated as it is established in NASA Procedural Requirement 8715.5, *Range Safety Program*, as a level of assessed risk to property that the Agency accepts for all range operations without higher management review. As defined by the local range (*i.e.,* PFRR), "property" requiring protection can be certain high-value equipment, assets, or other features. Additionally, a 1 in 100 chance (1×10^{-2}) was evaluated, as it is the criterion established by PFRR as the maximum allowable probability of impacting outside of the range boundaries.

A key consideration in determining the reasonableness of this alternative is whether NASA could still conduct its missions within the confines of the newly adopted criteria. To evaluate this question, NASA calculated the probabilities of landing within sensitive features for its past 10 years of sounding rocket flights at PFRR. Under this scenario, a mission could not be conducted if the probability of landing within a single feature (such as one of the four designated Wild Rivers in the launch corridor) exceeded the specified criterion. The past 10 years dataset was chosen as it is expected to closely resemble the next 10 years of activity.

Figure 2–41 depicts the predicted impacts of a 1 in 1,000 criterion for Wilderness Areas on future launches. While this restriction would have modest impacts on medium-range vehicles (*e.g.,* Terrier-Orion, Black Brant IX), it would have major effects on launching Black Brant XIIs and single- stage Orions. The greatest contributor to the higher risk of the Black Brant XII is the impact location of its third stage motor in relation to Mollie Beattie Wilderness Area and the typical trajectory of the Orion, which places its impact in the general vicinity of the Yukon Flats NWR recommended Wilderness Areas. **Figure 2–42** depicts the modest impacts of a 1 in 100 criterion for Wilderness; a limited number Terrier-Orion, Black Brant IX, and Black Brant XII missions would be excluded. It is important to note that while a particular mission would meet a criterion for a particular feature (*e.g.,* Wilderness Areas), it could still exceed the criterion for another feature (*e.g.,* Wild River Corridors). This is especially apparent when assessing the probability of impact within Mollie Beattie Wilderness Area and the Ivishak and Wind Rivers. While a majority of missions could meet the 1 in 100 criterion for Mollie Beattie Wilderness Area, they would still have greater probabilities for the two Wild River Corridors, and therefore would still be excluded as described below.

Figures 2–43 and **2–44** depict the expected impacts on future sounding rocket launches from voluntary adoption of 1 in 1,000 and 1 in 100 criteria for Wild River Corridors, respectively. Adoption of 1 in 1,000 criteria would essentially result in the discontinuation of sounding rocket flights from PFRR due its elimination of nearly all Black Brant-class vehicles and more than half of the Terrier-Orions. The primary contributor to the elevated risk is the northern trajectories of most moderate and long-range rockets, which must land within or adjacent to the Ivishak/Wind River area in Arctic NWR. For the 1 in 100 criterion, although impacts would be less in comparison, they would still be severe in that it would restrict most flights of the Black Brant XII and one-third and one-half of Terrier-Orion and Black Brant IX, respectively. In summary, the three vehicles that are expected to the most commonly specified to meet future scientific objectives at PFRR (Terrier-Orion, Black Brant IX, and Black Brant XII) would be those most affected by the adoption of numerical risk criteria for specially designated environmental features; therefore, this alternative was eliminated from detailed study in this EIS.

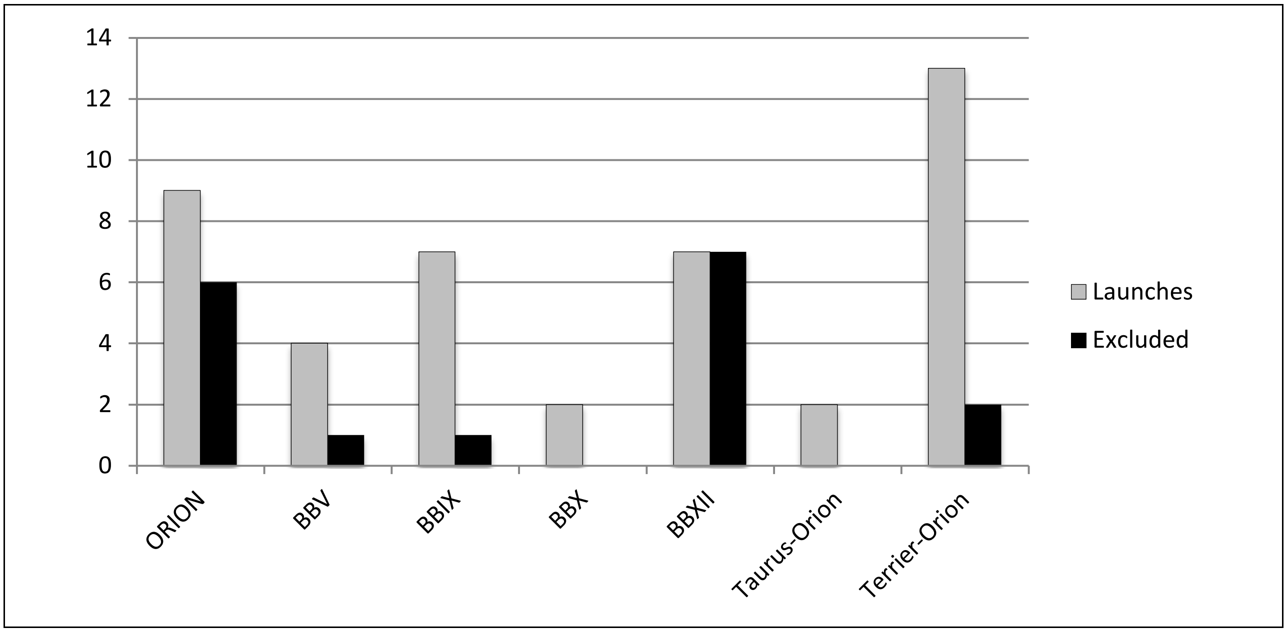


Figure 2–41. Effects of Adopting a 1:1,000 Risk Criterion for Wilderness Areas

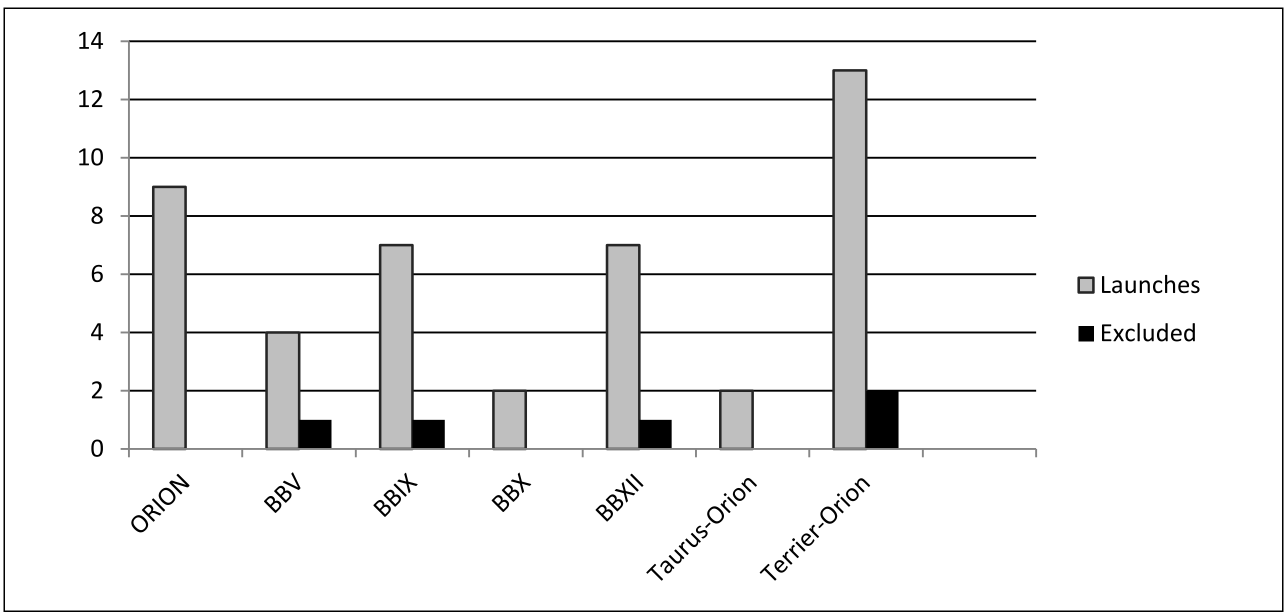


Figure 2–42. Effects of Adopting a 1:100 Risk Criterion for Wilderness Areas

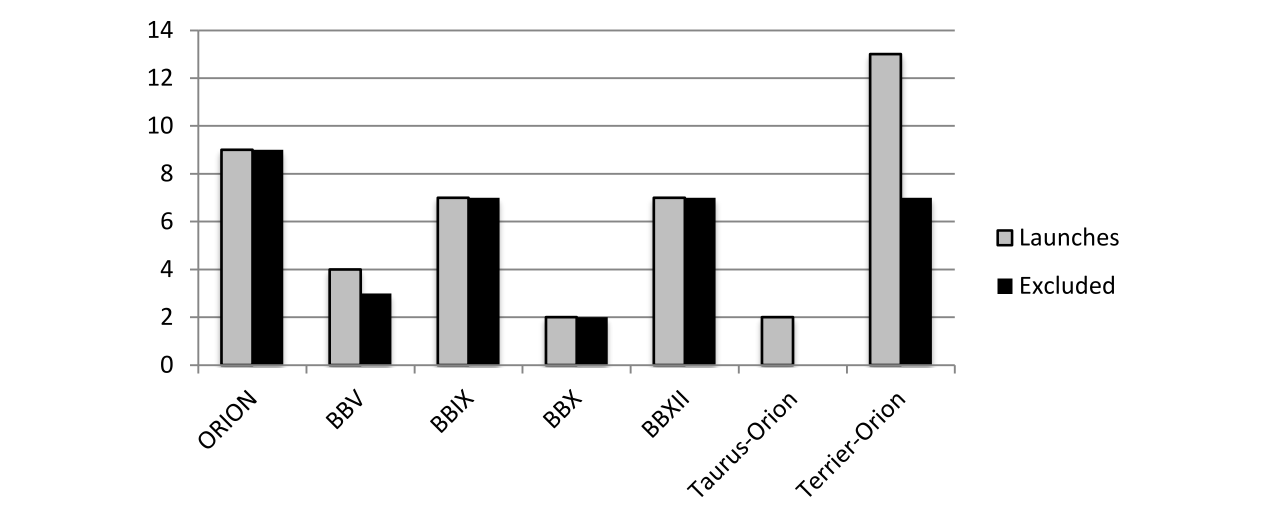


Figure 2–43. Effects of Adopting a 1:1,000 Risk Criterion for Wild River Corridors

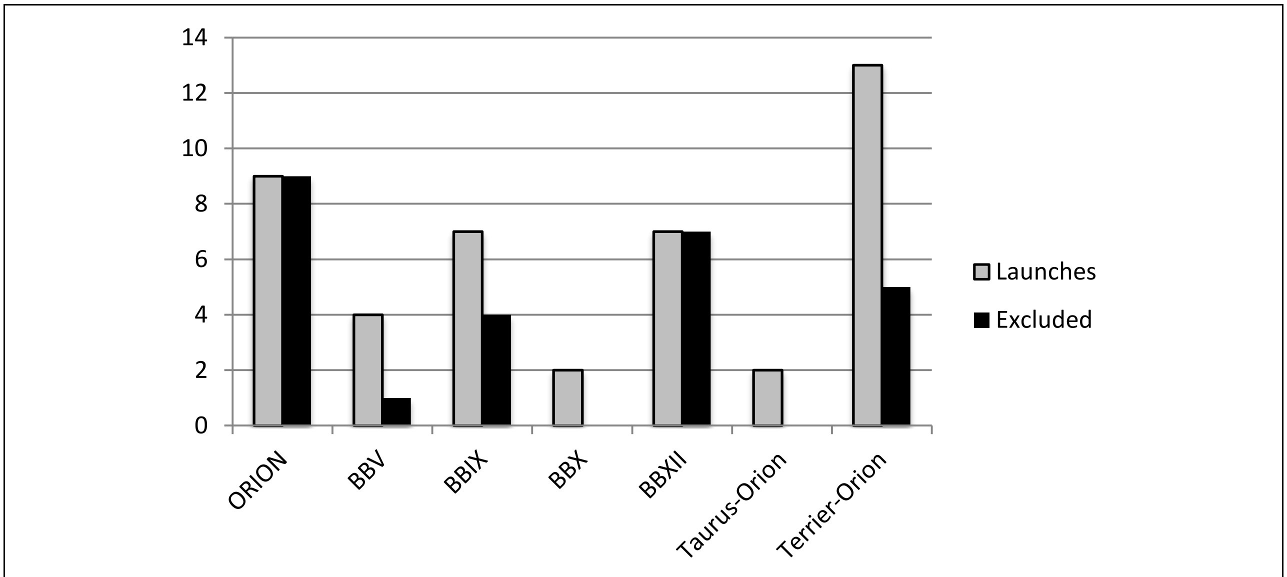


Figure 2–44. Effects of Adopting a 1:100 Risk Criterion for Wild River Corridors

2.4.7 Launching Easterly into Canada

Although there are current PFRR-specific criteria for avoiding the overflight of, or landing rocket hardware within, Canada, and the optimum launch azimuths are toward the north (to meet scientific requirements), comments received during scoping for this EIS prompted NASA to evaluate this possibility. Launching easterly into Canada potentially could meet some science objectives and would reduce the potential for flight hardware landing within environmentally sensitive areas in the U.S.; however, additional information was needed to determine if it could be done safely. Employing the same methodology and risk criteria that are used for calculating flight safety acceptability within PFRR, NASA considered the potential for launching its multi-stage Brants (*i.e.*, Black Brants IX, X, XI, and XII) along more easterly azimuths. This “family” of rockets was selected due to its growing use at PFRR by the science community and because they are the longest-range vehicles that would have the greatest potential of landing within a designated Wilderness or Wild River corridor.

Using trajectory data from a recent flight of each vehicle, NASA evaluated a wide range of azimuths and multiple launcher elevation settings to identify trends that could lead to the decision that the alternative could be considered "reasonable" for detailed evaluation in this EIS. The analysis concluded that the Black Brant IX generally had acceptably safe risk probabilities; however, with the exception of several Black Brant XI launcher settings and azimuth combinations, neither of the other vehicles met requisite range safety criteria **(Choquette 2012)**. The primary concern was that the probability of landing within a town or populated area would be too high. Therefore, NASA concluded that launching easterly from PFRR into Canada would be dismissed from further consideration in this EIS.

2.4.8 Track all Future Stages and Payloads

Another means to potentially reduce the environmental impact of the NASA SRP at PFRR would be to track all major components of the rocket from launch to impact, thereby improving the likelihood of all items being recovered. To enable this alternative, it would be necessary for NASA to make either of two key changes to its operations at PFRR. The first would consist of limiting the types of rockets launched from PFRR; the second would require the installation of additional tracking assets.

2.4.8.1 *Limiting the Configurations of Rockets Launched*

Currently, there is only a single tracking radar at PFRR; this system can only track a single object during flight. As a result, the facility's radar system is assigned to a beacon onboard the payload. Assuming no additional tracking infrastructure was provided at the range, this alternative would force NASA into launching only single-stage rockets such as the Improved Orion or the Black Brant V. Even in this case, the radar would still be assigned to the payload's onboard beacon rather than the rocket motor; however, the single stage and payload would be expected to impact within the same general area, potentially improving the ability to locate both items.

However, multi-stage rockets such as the Terrier-Improved Orion and Black Brant XII, are essential to the science conducted at PFRR. As such, without the ability to fly these configurations, most of the scientific objectives of the program could not be met. Therefore, this option was dismissed from further study. However, a potential remedy to this issue could be the installation of additional tracking infrastructure, whether at PFRR or at a downrange site.

2.4.8.2 *Installation of Additional Tracking Equipment*

NASA evaluated the installation of additional tracking stations both at the PFRR launch site and at locations downrange and identified three potential options **(LJT 2012)** that are summarized below.

Multi-Object Tracking – Under this option, NASA would install two Multi-Object Tracking Radars (MOTRs) at PFRR or a downrange site for the benefit of obtaining predicted coordinates for each returning stage or payload. Although MOTRs are phased-array tracking radar that are able to track upwards of 40 objects at a time (existing radars operated by NASA at PFRR are single object trackers), two systems would be needed to ensure proper function. Installation of each MOTR would require pouring a permanent concrete pad. Power requirements would be similar to the existing radar, but the radar would require extra infrastructure (including power, communications, data lines, etc.).

Midrange Deployment – Under this option, NASA would deploy a mobile radar (shown in **Figure 2–45**) to a midrange site. By locating the radar in the midrange region, it would have a better tracking vantage to follow an upper stage further to the ground than would be capable from the PFRR launch site. NASA currently has one mobile radar, which is the most easily transported type of tracking radar and could be used in this application. It consists of a tripod-mounted radar; a trailer to transport the radar, and a control van trailer. A mobile power system would also need to accompany the radar. The most reasonable site for such an installation would be Fort Yukon due to its existing infrastructure (power and communications) and amenities for the radar crew. It is also located in the middle of the Yukon Flats, which gives it better coverage of a stage falling to the ground in nearly any direction. Fort Yukon has a runway for crewmember transportation, but the radar itself would need to be barged in on the Yukon River or airlifted by helicopter from Fairbanks as there are no roads to Fort Yukon. The radar systems are too large to be loaded onto a C-130, which is the largest transport plane that can land at Fort Yukon. Helicopter airlift would require substantial work.

Figure 2–45. Tripod-type mobile radar (shown on an elevated platform)

Downrange Deployment **–** Under this option, NASA would deploy a mobile radar at a downrange site such that it would have improved visibility of the stages that land within the most northern regions of Alaska. Due to the local horizon at PFRR (and the fact that the existing radar is actually in the bottom of a valley for other technical reasons), the PFRR radar loses track of the upper stages much sooner than a radar that is closer to the impact site. For a downrange site, the existing portable radar would again be the preferred system, and the site location would be the University of Alaska's Toolik Lake Field Station, north of the Brooks Range. The station was selected for evaluation based on its available infrastructure (power and communications), amenities, and it is adjacent to the Dalton Highway. No airfield exists; therefore all personnel and equipment would need to travel along the Highway.

Costs – NASA estimated that the cost of a single MOTR system and foundation would be in excess of $7.5 million; therefore the two systems necessary would require an approximately $15 million investment. Midrange deployment of the existing NASA-owned radar would require approximately $400-700,000 to upgrade its trailer such that it could be safety transported to the its downrange site. It is expected that one-way transportation costs to Fort Yukon or Toolik Lake would be approximately $120,000-$240,000, depending upon whether the radar system would remain in place year round. Given that the system would also be required to serve other NASA missions besides those at PFRR, it is likely that it would require transportation back to WFF following each launch season. The purchase price of an equivalent new mobile system, which would also be needed to track each additional stage or payload, would be approximately $7 million. **Table 2–10** below provides a summary of the assets needed and estimated costs for implementing these downrange infrastructure options. Data are presented as a function of the two rockets most commonly launched from PFRR, the Terrier-Improved Orion and Black Brant XII. It is assumed that no tracking asset would be assigned to items landing within the ADNR Poker Flat North and South lands given their legal designation as rocket landing areas and close proximity to the launch site (resulting in much smaller dispersions). Also assumed is that the existing radar at the PFRR launch site would be assigned to the rocket's main payload, as is current practice.

Table 2–10. Downrange Tracking Assets and Associated Costs for Tracking Multiple Sounding Rocket Items at PFRR

	Terrier-Improved Orion	Black Brant XII
Stage 1 Tracking Asset	None	None
Stage 2 Tracking Asset	NASA-owned mobile radar transported to Fort Yukon	NASA-owned mobile radar transported to Fort Yukon
Stage 3 Tracking Asset	Not applicable	New Mobile Radar transported to Toolik Lake
Stage 4 Tracking Asset	Not applicable	None
Installation Cost	$520,000 to $940,000	Single Site: $520,000 - $940,000 Two Sites: $7.5 million - $7.9 million

Technical Limitations of Options Considered – For all options considered, the radar systems would be required to rely on a "skin track" due to the prohibition of installing radar beacons on rockets motors. This limitation reduces the distance to which an item can be tracked due to reduced power in the return signal. For the radar systems considered in this evaluation, NASA estimated that the maximum range for a "skin track" is approximately 125 kilometer (80 miles), which for systems located at PFRR (such as a MOTR) would provide little benefit for tracking impacts on lands north of the White Mountains NRA. If the stage were to travel farther (which most do), the remainder of the trajectory must be propagated by software to the predicted impact point as is currently done. Locating radar at multiple sites downrange (as described above) would improve the ability to track stages further downrange; however, it would still not be possible to reasonably cover all areas within the range boundaries.

The elevation of terrain downrange of PFRR also limits the precision of tracking and landing data obtained by PFRR-based equipment. The elevation of the launch site at PFRR is approximately 200 meters (660 feet) msl, while mountains north of the launch and within PFRR can reach over 2,700 meters (9,000 feet). Therefore, radar-based tracking technology used at PFRR can only predict an impact location within a certain radius downrange. For multi-stage rockets, the uncertainty may be up to 32 kilometers (20 miles). For tracking assets installed at downrange sites, this radius of uncertainty would be smaller; however, when coupled with the remote nature of the terrain, it would not present a substantially better alternative for locating items at longer-range impact sites, especially when the cost of installing such a system is considered.

Additionally, as the rockets would be launched from a site that would not be visible from the mobile radar's location at either downrange location, it will be required to send real-time data from a source at the launch site to the mobile radar to provide it a location to acquire the target. Precision tracking radars typically have a beam that is on the order of 1 degree wide, meaning it would need to be pointed directly at the target in order to track. This would require reliable data circuits with minimal delay. While this has been done in the past, the appropriate solution would require modern data transmission circuits that may not be available at the remote locations.

Impact Prediction Versus Location and Recovery – For all options discussed above, it is unlikely that the radars, even when placed at their proposed locations, would likely track a stage to ground impact. While NASA's impact prediction tools are well refined and consistent with those employed at other U.S. launch ranges, the actual location of the stages must be conducted by flying an aircraft over the reported impact areas and visibly searching for a relatively small object. Depending upon the angle that the spent rocket stage or other equipment impacts the ground and the conditions on the ground at the time of impact (*e.g.,* snow or very wet conditions), there may be anything from a piece of angled rocket body or tailfin visible to nothing visible. It is possible that a spent stage may come relatively straight down and bury itself upon impact. Even if the radars could be reasonably located such that they could track to impact, unless there is a locating device on the item (which is only technically feasible for parachuted payloads as discussed in Section 2.1.7.2), NASA cannot guarantee that it would be found.

Summary – In summary, given the substantial costs associated with the installation of additional tracking infrastructure, the inherent limitations of available technologies, and the limited expectation for improved location of items in downrange lands, NASA dismissed this alternative from further consideration in this EIS at this time.

2.5 SUMMARY COMPARISON OF THE ALTERNATIVES

This section summarizes both the key components and potential impacts on resources under the *PFRR EIS* alternatives described in Section 2.3. Detailed descriptions and in-depth discussions of impacts on resources are provided in Chapter 4, "Environmental Consequences."

Table 2–11 provides a summary of the features of the proposed alternatives. **Table 2–12** lists the potential impacts of implementing the alternatives evaluated in this *PFRR EIS* per resource area.

Table 2–11. Summary of the Features of the Proposed Alternatives

Component	Alternative				
	No Action	**1**	**2**	**3**	**4**
Continue launches at PFRR as in the recent past; average 4 per year, 8 maximum	✓	✓	✓	✓	✓
Avoid planning impacts within designated Wilderness Areas	✓	✓	✓	✓	✓
Recover newly expended stages and payloads only if it is part of the science plan or it is needed for programmatic objectives	✓				
Develop funded Recovery Program that allows for reasoned decisionmaking to support search and recovery of newly expended and historic stages and payloads		✓	✓	✓	✓
Conduct post-launch search for all primary land-impacting items; attempt recovery if located		✓	✓	✓	✓
Establish public notification and rewards program to encourage assistance of downrange land users in locating items launched in past, regardless of sponsoring organization (*i.e.*, both NASA and non-NASA sounding rocket items)		✓	✓	✓	✓
When an item is located, maintain ability to leave all or part of it in downrange lands if full removal would result in greater overall environmental damage		✓		✓	
When an item is located, full removal would be required as long as recovery crew are not endangered			✓		✓
Restrict trajectories of future PFRR missions to lessen the possibility of projected impacts in designated Wild River corridors				✓	✓

Key: NASA=National Aeronautics and Space Administration; PFRR=Poker Flat Research Range; SRP=Sounding Rockets Program.

Table 2–12. Summary of Potential Impacts by Alternative

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Air Quality	*No*	Routine Operations – Emissions from facility heating, employee transportation, etc., would be regional in scope and adverse, but minor and long-term in duration. Rocket Launches – Emissions from rocket motors and payloads would be global in scope, adverse, minor and short-term in duration. Search and Recovery – Emissions from search and recovery vehicles would be regional in scope and adverse, but minor and medium-term in duration. *Least impact of the Alternatives.* Summer Launches – No measurable difference from winter launches would be expected.	Same as the No Action Alternative; however, slightly greater emissions due to more search and recovery operations.	Same as Alternative 1; however, slightly greater emissions due to the most recovery operations. *Greatest impact of the Alternatives.*	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Global Atmosphere	*No*	<u>Rocket Launches</u> – A small, temporary, local stratospheric ozone reduction effect could occur in the wake of upper-stage rockets, but no globally noticeable effects would be expected, resulting in minor, long-term adverse impacts. <u>Search and Recovery</u> – Greenhouse gas emissions (and resulting climate change impacts) from search and recovery vehicles would be global, adverse, minor, and long-term. *Least impact of the Alternatives.* <u>Summer Launches</u> – No measurable difference from winter launches would be expected.	Same as the No Action Alternative; however, slightly greater emissions due to more search and recovery operations.	Same as Alternative 1; however, slightly greater emissions due to the most recovery operations. *Greatest impact of the Alternatives.*	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Water Resources	*No*	**Surface Water Quality:** <u>Rocket Launches</u> – Adverse impacts on surface water would be localized, negligible, and short-term. Long-term adverse impacts from remaining flight hardware would be greatest; however, localized. *Greatest impact of the Alternatives.* <u>Search and Recovery</u> – Limited search and recovery would result in the least potential for causing short-term turbidity during land disturbance; also least potential for accidental petroleum spill from recovery equipment. **Groundwater Quality:** Negligible effects would be expected.	Same as the No Action Alternative, except additional short-term surface water impacts would be possible due to increased search and recovery activities. Also, long-term impacts of remaining flight hardware would be lesser due to greater recovery.	Same as Alternative 1, except additional surface water impacts would be expected due to increased search and recovery activities. Also, long-term impacts of remaining flight hardware would be lesser due to greater recovery.	Same as Alternative 1. The restricted trajectories would be the least impactful on designated Wild Rivers because they could lessen the already low probabilities that spent stages or payloads would land within them. *Least impact of the Alternatives.*	Same as Alternative 2. The restricted trajectories would be the least impactful on designated Wild Rivers because they could lessen the already low probabilities that spent stages or payloads would land within them.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Water Resources (*continued*)		**Wild Rivers:** Effects on the physical and chemical integrity would be adverse, localized, negligible, and short-term. Effects on other Wild River values are discussed under Land Use and Recreation. <u>Summer Launches</u> – More immediate interaction of flight hardware with surface water or groundwater would be expected.				
Geology and Soils	*No*	<u>Rocket Launches</u> – No impacts on PFRR launch site or launch corridor soil chemistry would be anticipated from the corrosion of metal items; no adverse impacts would be expected due to erosion from the disturbance at the landing site; impacts would be localized and confined to the immediate vicinity of the landing site.	Similar to the No Action Alternative; however, additional isolated soil disturbances would be possible due to larger recovery efforts from activities such as hand digging around a landing site.	Minor soil disturbances beyond the No Action Alternative and Alternative 1 could be expected due to additional recovery efforts. *Greatest impact of the Alternatives.*	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Geology and Soils (*continued*)		<u>Search and Recovery</u> – Due to the limited recovery efforts, potential adverse effects from soil erosion would be minor in magnitude and medium-term in duration. *Least impact of the Alternatives.* <u>Summer Launches</u> – Indirect impacts could result from the increased likelihood of a wildfire starting as a result of a spent stage igniting such a fire.				
Noise	*No*	<u>Routine Operations</u> – Routine PFRR activities, including the use of employee vehicles and delivery vehicles, would result in regional, adverse, long-term, and minor impacts. <u>Rocket Launches</u> – Noise generated by the propulsion and reentry of sounding rockets would be regional and adverse, however; short-term and minor in intensity.	Same as the No Action Alternative, except more noise would be expected due to increased search and recovery activities.	Same as Alternative 1, except more noise would be expected due to increased search and recovery activities. Impacts would be expected to be regional in scope, adverse, medium-term in duration, and moderate in intensity.	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Noise (*continued*)		<u>Search and Recovery</u> – Noise generated from search and recovery vehicles would be short-term, and infrequent, resulting in adverse impacts that would be regional in scope, medium-term, and minor. *Least impact of the Alternatives.*		*Greatest impact of the Alternatives.*		
Visual Resources	*No*	<u>PFRR Launch Site</u> – No measurable changes to the appearance of the PFRR launch site would occur. <u>Rocket Launches</u> – Impacts from a person witnessing a launch could be either beneficial or adverse, depending upon the person. However, in either case, effects would be minor and short-term. <u>Search and Recovery</u> – Short-term, minor, adverse impacts would be expected if someone witnessed a search or recovery flight. However,	Same as the No Action Alternative, except there would be a greater potential for a land user to witness a search or recovery flight. Due to greater recovery efforts, the reduced likelihood of land users encountering flight hardware would result in	Same as Alternative 1; however, slightly greater short-term impacts could occur from more recovery flights. Long-term, more items would likely be removed from downrange lands; however, a more aggressive recovery policy could result in localized ground scars or ruts,	Same as Alternative 1, except a restriction on planned impacts within Wild Rivers could further reduce potential effects on aesthetics. *Least impact of the Alternatives.*	Same as Alternative 2, except a restriction on planned impacts within Wild Rivers could further reduce potential effects on aesthetics.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Visual Resources (*continued*)		the long-term presence of remaining stages or payloads in downrange lands could range from minor to moderate depending on location. Whether the impact would be beneficial or adverse would be dependent upon the interpretation of the person discovering it. *Greatest impact of the Alternatives.* No change in BLM Visual Resource Management classification would be anticipated. <u>Summer Launches</u> – Due to the absence of frozen ground/ice, there would be a greater potential for spent stages to become buried in shallow bogs/sloughs (particularly in wetland areas of Yukon Flats NWR), resulting in a lower likelihood of a land user encountering such materials.	fewer impacts over the long-term.	which could degrade the natural appearance of an area.		

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Ecological Resources	*No*	**Vegetation:** <u>Rocket Launches</u> – No impacts are anticipated at the launch site. Adverse impacts would be restricted to the area immediately surrounding the landing location of flight hardware, diminishing rapidly as distance from the point increases. Therefore, effects would be local in scope, short-term in duration, and negligible in intensity. <u>Search and Recovery</u> – Negligible adverse impacts would occur because only small, isolated areas would be affected and vegetation would regenerate. *Least impact of the Alternatives.*	Same as the No Action Alternative, except increased vegetation disturbance would occur due to additional recovery efforts; increased potential for terrestrial wildlife and avian disturbance — localized, short-term, and minor impacts.	Same as Alternative 1; however, short-term adverse impacts on vegetation and wildlife could be greater due to more intensive recovery efforts. *Greatest impact of the Alternatives on both Vegetation and Wildlife.*	Same as Alternative 1, except decreased potential for wildlife impacts within Wild River corridors due to restricted trajectories.	Same as Alternative 2, except decreased potential for wildlife impacts within Wild River corridors due to restricted trajectories.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Ecological Resources (*continued*)		**Wildlife:** Rocket Launches – The risk of a direct strike or startle during rocket flight and reentry would be highly unlikely, resulting in local, short-term adverse impacts. Search and Recovery – Adverse effects (*e.g.*, startle) on wildlife species could occur during search and recovery flights and when personnel are working on the ground; however, effects would be very infrequent, local, and short-term. *Least impact of the Alternatives.*				

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Ecological Resources (*continued*)		**Special Status Species and Habitat:** No adverse effects would be expected on essential fish habitat, target species, or subsistence species. NASA is consulting with USFWS and NOAA Fisheries regarding potential effects on listed, proposed, and candidate species under their respective jurisdictions. Summer Launches – More vegetation would be exposed due to a lack of snow cover, resulting in a higher degree of impact. There would also be an increased risk of unintentional wildfire from hot re-entering flight hardware. Regarding wildlife, there would be a greater potential for spent stages/payloads to land near wildlife because more species would be present, potentially causing short-term behavioral response such as flight.				

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Land Use and Recreation	*Yes, No Action Alternative*	**Land Use:** Rocket Launches – Launches would be consistent with permits and authorizations issued by landowners. No planned impact locations would be permitted within Mollie Beattie Wilderness; however, impacts could occur with designated Wild River corridors. Search and Recovery – Because most recent USFWS- and BLM-issued permits for PFRR operations require the recovery of flight hardware, this alternative would not be fully consistent with the terms and conditions of the use permits, and would not likely be authorized by the land management agencies. *Greatest impact of the Alternatives.*	**Land Use:** Impacts from launches would be the same as the No Action Alternative; however, increased recovery efforts would assist UAF in complying with permit requirements and memoranda of agreement with landowners. **Recreation:** There would be a reduced likelihood of a recreational user encountering flight hardware due to additional recovery efforts, but negligible, short-term impacts on recreational users in areas within the PFRR	Impacts would be the same as Alternative 1, except there would be increased potential for outward signs of more invasive recovery operations, affecting wilderness character of the lands, and increased likelihood of recreational users observing flights overhead due to recovery efforts.	Same as Alternative 1 except the reduced likelihood of flight hardware landing in Wild Rivers would reduce the need for recovery efforts in these areas. Least impact of the Alternatives on both Land Use and Recreation.	Same as Alternative 2, except the reduced likelihood of flight hardware landing in Wild Rivers would reduce the need for recovery efforts in these areas.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Land Use and Recreation (*continued*)		**Recreation:** Rocket Launches – The ability of persons to visit or take part in recreational activities within downrange lands would not be restricted. Search and Recovery – Limited search and recovery efforts would result in the least potential for witnessing a recovery operation; however, it would result in the greatest deposition of flight hardware in downrange lands. Impacts could be beneficial or adverse, depending on user perception; localized; minor in intensity, and short-term to long-term in duration, depending on how long the known payloads and spent stages remain within the launch corridor. *Greatest impact of the Alternatives.*	launch corridor would be expected from recovery flights. It is expected that in most cases, the long-term impacts of leaving a piece of flight hardware within the downrange lands would be greater than the short-term disturbances (*e.g.*, noise, aircraft overflight) associated with recovery.			

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Land Use and Recreation (*continued*)		<u>Summer Launches</u> – Greater impacts would be expected due to the larger user base in downrange lands.				
Cultural Resources	*No*	<u>Rocket Launches</u> – There would be an extremely low probability of flight hardware impacting/damaging cultural/religious sites. Winter launches likely reduce the potential impact on a cultural resource site because snow/ice/frozen ground reduces surface and subsurface damage. NASA would continue to coordinate with agencies and Alaska Natives according to Section 106 of the National Historic Preservation Act. <u>Search and Recovery</u> – Least recovery-related chance of impacting cultural site of the alternatives due to limited recovery activities. *Least impact of the Alternatives.*	Same as the No Action Alternative, except greater possibility of disturbing a historic site because greater number of recovery activities compared with the No Action Alternative.	Same as Alternative 1. Alternative 2 entails the greatest recovery effort and could present the highest risk of resource damage. However, negligible impacts expected due to low probability of landing on or adjacent to a cultural site. *Greatest impact of the Alternatives.*	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Cultural Resources (*continued*)		<u>Summer Launches</u> – Greater effect on impact point due to thawed ground, but extremely low probability of rocket impacting cultural site.				
Subsistence Resources	*No*	<u>Rocket Launches</u> – There would be negligible chances of a payload or spent stage striking or disturbing an individual animal; therefore, adverse effects on subsistence activities are expected to be negligible-to-minor and short-term. <u>Search and Recovery</u> – Recovery operations have the potential to disturb game species; therefore, temporarily impacting subsistence hunting. However, recoveries would be infrequent and impacts would be minor and short-term. Least impact of the Alternatives.	Same as the No Action Alternative; however, greater search and recovery operations could result in greater impacts on subsistence resources or the harvest of subsistence resources. However, impacts are still expected to be localized, minor, and short-term in duration.	Same as Alternative 1; however, greater search and recovery operations could result in greater impacts on subsistence resources or the harvest of subsistence resources. However, impacts are still expected to be localized, minor, and short-term in duration. *Greatest impact of the Alternatives.*	No measurable differences in potential impact with restricted trajectories; same as Alternative 1.	No measurable differences in potential impact with restricted trajectories; same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Subsistence Resources (*continued*)		Summer Launches – Greater potential impacts on subsistence activities due to larger presence of subsistence resources in downrange lands and waters. Minor direct impacts on fish and game. Requirements to maintain public safety could result in areas being avoided (either voluntarily or mandatorily) by subsistence users who would otherwise be hunting or fishing, which would be an adverse effect.				
Transportation	*No*	Traffic Fatalities – There would be a minor risk due to truck transports: about 1 chance in 500 years. Traffic Volume – Negligible impact would be expected due to truck transports related to launch and search and recovery operations.	Same as the No Action Alternative, except greater air transport incident risk, at 1 chance in 770 years, due to more flight time during recovery operations; this is a very low	Same as Alternative 1, except greater air transport incident risk, at 1 chance in 480 years, due to more flight time during recovery operations; this is a very low probability and is considered a minor impact.	Same as Alternative 1, restricted trajectories would not change potential transportation impacts.	Same as Alternative 2, restricted trajectories would not change potential transportation impacts.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Transportation (*continued*)		Air Transport Incident Risk – Approximately 1 chance in 4,800 years of air transport fatality. *Least impact of the Alternatives.* Summer Launches – Same as winter launch transportation impacts because truck transports and aircraft operations associated with search and recovery activities would occur during the summer regardless of season launch took place.	probability and is considered a negligible impact.	*Greatest impact of the Alternatives.*		
Waste Management	*Yes, No Action Alternative*	Rocket Launches – With all launches, small quantities of potentially hazardous materials (*e.g.*, rechargeable batteries, insulation materials) would land within downrange lands. Under normal circumstances, these items would not be expected to pose a risk to persons, wildlife, or the environment. A net deposition of between	More materials would be removed from downrange lands than under the No Action Alternative. It is estimated that a total of approximately 1,400 to 2,800 kilograms (3,100 to 6,200 pounds) of newly launched	More material would be removed from downrange lands than under the No Action Alternative or Alternative 1. It is estimated that approximately 1,400 to 2,700 kilograms (3,100 to 6,000 pounds) of material associated with	Same as Alternative 1, restricted trajectories would not change potential quantities of wastes deposited in downrange lands; however, they could reduce the probability	Same as Alternative 2, restricted trajectories would not change potential quantities of wastes deposited in downrange lands; however, they could reduce the probability

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Waste Management (*continued*)		1,200 and 2,400 kilograms (2,650 and 5,300 pounds) of primarily non-hazardous material (*e.g.*, steel rocket motor casings, aluminum payload structures) would be deposited in downrange lands annually, resulting in a moderate to major, long-term, adverse impact. *Greatest impact of the Alternatives.* <u>Summer Launches</u> – Impacts would be the same as winter launches.	payloads and stages would be removed annually. Additionally, approximately 500 kilograms (1,100 pounds) of existing payloads and stages would be recovered per year, excluding the materials within the designated ADNR Poker Flat North and South lands. Flight hardware removal would be a long-term, moderately beneficial impact. A net reduction of 500 kilograms (1,100 pounds) up to a 900-kilogram (1,980 pounds) increase in materials, which	new launches would be recovered annually. Approximately 1,300 kilograms (2,900 pounds) of material associated with past launches would be recovered annually from PFRR, excluding the materials within the designated ADNR Poker Flat North and South lands. A total of approximately 2,700 to 4,000 kilograms (6,000 to 8,800 pounds) of newly launched and existing stages and payloads would be recovered from PFRR annually, excluding the	of flight hardware landing within Wild or Scenic River Corridors.	of flight hardware landing within Wild or Scenic River Corridors. *Least impact of the Alternatives.*

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Waste Management (*continued*)			would correspond to either a minor beneficial to minor adverse long-term impact.	materials within the designated ADNR Poker Flat North and South lands. A net reduction of 1,200 kilograms (2,600 pounds) up to a 100-kilogram (220 pounds) increase in materials, which would correspond to either a moderate beneficial to minor adverse long-term impact.		
Health and Safety	*No*	Rocket Launches – Public and worker health and safety impacts would be short-term and negligible. All launch operations would be conducted in accordance with NASA and PFRR safety criteria and mission-specific ground and flight safety plans.	Projected health impacts of search and recovery of 2 payloads and 10 stages per year would be about a factor of 6.4 to 9 times higher than the No Action Alternative, but still small, with no lost work day injuries or fatalities	Projected impacts of search and recovery of 4 payloads and 16 stages per year would be about a factor of 11 to 19 times higher than the No Action Alternative, but still small, with no lost work day injuries or fatalities expected per year of	Same as Alternative 1.	Same as Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Health and Safety (*continued*)		Search and Recovery – 0 annual fatal injury flight accidents, 0 occupational injuries during ground recovery operations, and 0 fatalities during ground recovery activities, based on normal injury and fatality rates for similar types of activities in Alaska. Summer Launches – There would be a higher potential safety risks due to higher population densities and greater potential for unintended impacts due to accidents, including fires started by incompletely burned stages.	expected per year of recovery operations.	recovery operations.		
Socioeconomics and Environmental Justice	*No*	**Socioeconomics:** ***Routine Operations*** Direct employment – 17 full-time equivalents per year. Indirect employment – 11 full-time equivalents per year.	**Socioeconomics:** Same as the No Action Alternative, except that greater search and recovery operations would result in greater economic input,	**Socioeconomics:** Same as Alternative 1, except that greater recovery operations would generate more economic input, resulting in minor,	Same as Alternative 1, restricted trajectories would not change potential socioeconomic or Environmental	Same as Alternative 2, restricted trajectories would not change potential socioeconomic or Environmental

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Socioeconomics and Environmental Justice (*continued*)		Direct economic activity – $1.9 million, $1.4 million of which in PFRR employee earnings. Indirect earnings – $640,000 within the ROI. Therefore, impacts would be minor, medium-term, and beneficial. Search and Recovery – Impacts would be negligible, though beneficial, over the medium-term; 0 indirect employment opportunities. *Least impact of the Alternatives.* Summer Launches – no change in socioeconomic impacts would be expected as compared to winter launches. **Environmental Justice:** Negligible-to-minor risks to health and safety of general population from NASA SRP normal operations, off-normal	this would be considered to be minor, beneficial, and medium-term. Direct employment from search and recovery is estimated to be 3 full-time equivalents. Economic activity would be approximately $166,000. **Environmental Justice:** Same as the No Action Alternative.	beneficial, and medium-term impacts. Direct employment from search and recovery is estimated to be 4 full-time equivalents. Economic activity would be approximately $282,000. *Greatest impact of the Alternatives.* **Environmental Justice:** Same as the No Action Alternative.	Justice impacts associated with Alternative 1.	Justice impacts associated with Alternative 2.

Resource Area	Potentially Significant Impact Identified?	No Action Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Socioeconomics and Environmental Justice (*continued*)		flights, and transportation; no adverse impacts on subsistence resources or users within the PFRR launch corridor due to launches and search and recovery operations. Therefore, no disproportionately high and adverse impacts on minority or low-income populations would be expected.				

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CHAPTER 3

DESCRIPTION OF THE AFFECTED ENVIRONMENT

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3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

In Chapter 3, descriptions of the area within the Poker Flat Research Range (PFRR) provide the context for understanding the environmental consequences of the alternatives described in Chapter 4. The affected environment serves as a baseline from which any environmental changes that may be brought about by implementing the proposed alternatives can be identified and evaluated; the baseline conditions are the currently existing conditions.

The affected environment at Poker Flat Research Range (PFRR) is described for the following resource areas: air quality and climate; water resources; geology and soils; noise; visual resources; ecological resources; land use and recreation; cultural resources; subsistence use resources; transportation; hazardous materials and waste; health and safety; and socioeconomics and environmental justice. For simplicity and consistency with PFRR launch seasons, the affected environment is divided into two seasons for some resources areas: summer and winter. For this analysis, summer is defined as May through September and winter, as October through April. In addition, for some resource areas, the affected environment description is based on ecoregions. The following ecoregions are located within the PFRR launch site, launch corridor, and are discussed in this *Draft Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)*: Beaufort Sea Ecoregion, Arctic Coastal Plain Ecoregion, Arctic Foothills Ecoregion, Brooks Range Ecoregion, Interior Forested Lowlands and Uplands Ecoregion, Interior Highlands Ecoregion, and Yukon Flats Ecoregion **(Gallant *et al.* 1995)**. For the purposes of discussion, PFRR is divided into two components: the launch site and launch corridor.

3.1 AIR QUALITY AND CLIMATE

3.1.1 Air Quality

Air pollution refers to the direct or indirect introduction of any substance into the air that could endanger human health; harm living resources, ecosystems, or material property (*e.g.*, buildings); or impair or interfere with the comfortable enjoyment of life or other legitimate uses of the environment. Air quality is affected by air pollutant emission characteristics, meteorology, and topography.

The U.S. Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants, as shown in **Table 3–1**. The State of Alaska has adopted the standards, as indicated in the table.

The region of influence (ROI) for air quality is defined as the area within the PFRR launch site and launch corridor, both of which are within the Northern Alaska Intrastate Air Quality Control Region Number 9. None of these areas are designated as nonattainment areas with respect to the NAAQS for criteria air pollutants **(40 CFR 81.302)**. The nearest nonattainment area is a part of Fairbanks North Star Borough, which has been designated nonattainment for particulate matter with an aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$).

Table 3–1. Federal and State Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS[a]	Alaska Ambient Air Quality Standards
		(micrograms per cubic meter)	
Carbon monoxide	8 hours 1 hour	10,000 40,000	10,000 40,000
Lead	Quarterly 3 months	N/A 0.15	1.5 N/A[b]
Nitrogen dioxide	Annual 1 hour	100 188	100 N/A[b]
Ozone	8 hours 1 hour	147 N/A	N/A[b] 235
PM_{10}	Annual 24 hours	c 150	50 150
$PM_{2.5}$	Annual 24 hours	15 35	b b
Sulfur dioxide	Annual 24 hours 3 hours 1 hour	80 365 1,300 197	80 365 1300 N/A[b]

a. The more stringent of the primary and secondary standards is presented if both exist for the averaging period. The standards for carbon monoxide and the 24- and 3-hour standards for sulfur dioxide are not to be exceeded more than once per year. The annual arithmetic mean $PM_{2.5}$ standard is attained when the weighted annual arithmetic mean concentration (3-year average) does not exceed the standard value. The 24-hour $PM_{2.5}$ standard is met when the 98th percentile over 3 years of 24-hour average concentrations is less than or equal to the standard value. The 24-hour PM_{10} standard is met when the standard value is not exceeded more than once per year over a 3-year period. The annual arithmetic mean PM_{10} standard is attained when the weighted annual arithmetic mean concentration (3-year average) is less than or equal to the standard value. The Federal 1-hour nitrogen dioxide standard is met when the 3-year average 98th percentile of the daily maximum 1-hour average does not exceed the standard value. The Federal 1-hour sulfur dioxide standard is met when the 3-year average 99th percentile of the daily maximum 1-hour average does not exceed the standard value. The Federal 3-month lead standard is met when the maximum 3-month mean for a 3-year period does not exceed the standard value.

b. The State of Alaska has not yet adopted the Federal standard.

c. The U.S. Environmental Protection Agency revoked the annual PM_{10} standard.

Key: N/A=not applicable; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

Source: 18 AAC 50.010; 40 CFR 50; 71 FR 61144.

Routine monitoring of air pollutants is not conducted at PFRR. Monitoring of carbon monoxide and $PM_{2.5}$ is performed at monitors in Fairbanks North Star Borough. Monitored values for carbon monoxide are well below the ambient standards **(USEPA 2011a)**. Elevated concentrations of $PM_{2.5}$ have occurred in Fairbanks during the winter partially because of wood-fired devices and during summer because of wildfires. The state does not routinely monitor for other criteria pollutants nearby.

A summary of emissions of criteria pollutant emissions for Fairbanks North Star Borough is presented in **Table 3–2**. The primary sources of air pollutants in Fairbanks North Star Borough are power plants, refining, and airports **(USEPA 2011b)**. Other sources include traffic (snow machines, automobiles, aircraft, motorboats, and other vehicles) and fires.

Table 3–2. Fairbanks North Star Borough Criteria Pollutant Emissions, 2008

Pollutant	Metric Tons Per Year
Carbon monoxide	19,800
Lead	0.287
Nitrogen oxides	4,040
PM_{10}	14,700
$PM_{2.5}$	1,870
Sulfur dioxide	2,090
VOCs[a]	3,480

a. VOCs (volatile organic compounds) are a precursor of ozone.
Note: To convert metric tons to tons, multiply by 1.1023.
Key: PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.
Source: **USEPA 2011c.**

Activities at PFRR produce criteria air pollutants and other air pollutants in various quantities. Launch vehicles emit lead, carbon monoxide, particulate matter, and other pollutants into the lower atmosphere **(NASA 2000a)**. Emissions from various launch vehicles used in the National Aeronautics and Space Administration (NASA) Sounding Rockets Program (SRP) into the lower atmosphere and the upper atmosphere are presented in the *Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* **(NASA 2000a)**, and emissions from launch vehicles used at PFRR are presented in Chapter 4. Some payloads of previous launches at PFRR have released TMA [trimethylaluminium] (a mixture of trimethyl aluminum and triethyl aluminum), barium, and calcium **(NASA 2000a)**. Other than launch vehicles, sources of air at PFRR include generators, heating systems, delivery vehicles, and employee vehicles **(NASA 2011a**). Search and recovery work also results in air pollutant emissions from aircraft operations and use of various vehicles. Estimated PFRR emissions are presented in **Table 3–3**. The table includes estimated carbon dioxide emissions resulting from production of electricity used for PFRR operations.

Table 3–3. Poker Flat Research Range Annual Emissions

Pollutant	Heating	Internal Combustion	Electric Generation[a]
	Metric Tons Per Year		
Carbon monoxide	0.022	15	NR
Nitrogen oxides	0.11	2.9	3.9
PM_{10}	0.0048	0.2	NR
$PM_{2.5}$	0.0037	0.2	NR
Sulfur dioxide	0.00094	0.02	1.9
Carbon dioxide	96	130	1,900

a. Indirect emissions from offsite electric generation were based on the air pollutant emission rate for the Alaska grid and average annual electric use at Poker Flat Research Range for the period from 2008–2010.

Note: To convert metric tons to tons, multiply by 1.1023.

Key: NR=Emission rates for particulate matter and carbon monoxide are not reported in eGRIDweb; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers.

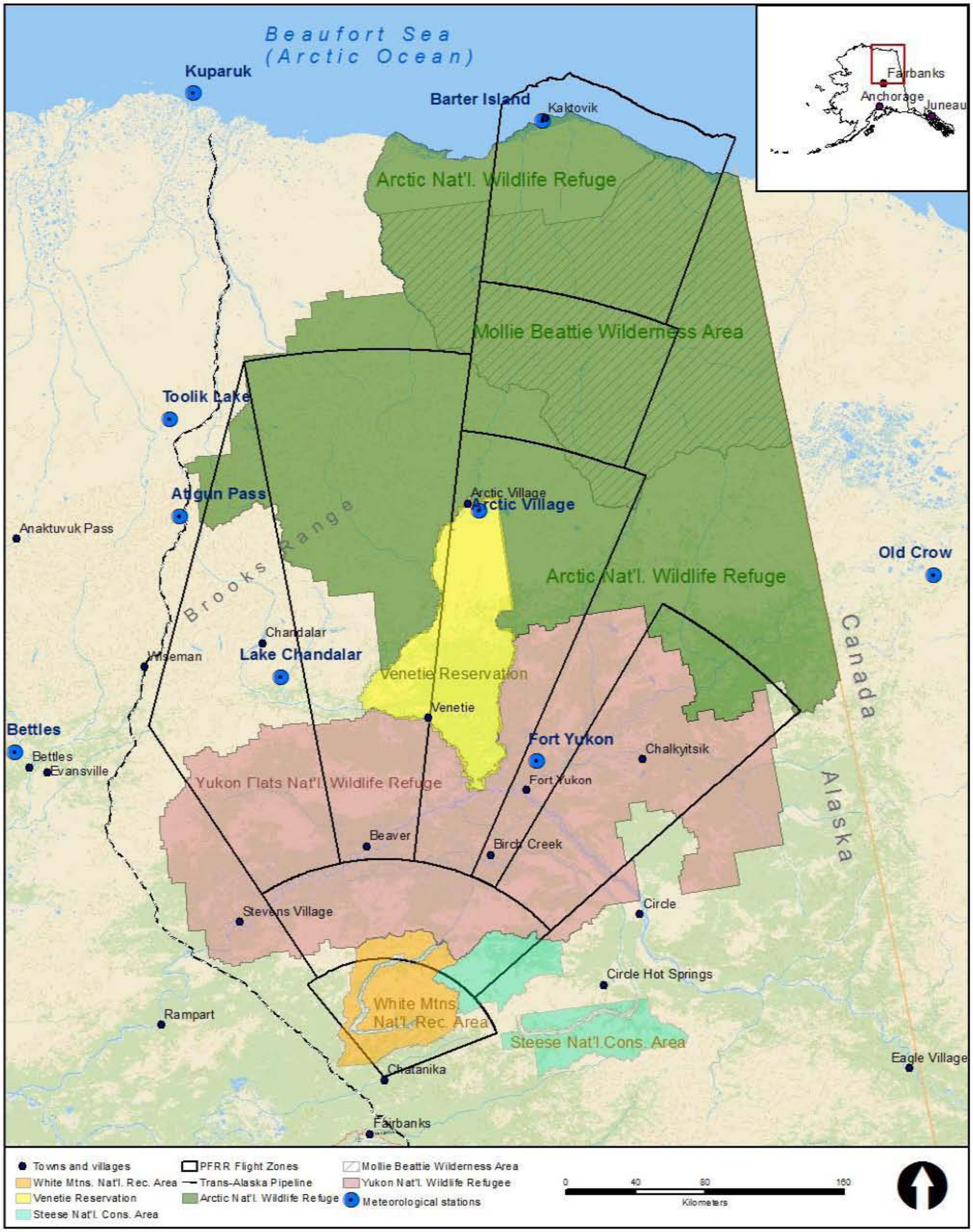
Source: NASA 2011a.

3.1.2 Climate

The climate within PFRR, shown in **Figure 3–1,** varies significantly from the south to the north and is dependent upon latitude, elevation, terrain, and proximity to the Beaufort Sea. The ROI can be divided into three different climate regimes: (1) the southern regime, which includes the PFRR launch site, White Mountains NRA, and Yukon Flats NWR; (2) the central regime, which includes the southern half of Arctic NWR, including Brooks Range and most of the Mollie Beattie Wilderness Area; and (3) the northern regime, which includes the northern half of Arctic NWR, including the Beaufort Sea Coastal Plain and the Brooks Range Foothills, and the northeast corner of the Mollie Beattie Wilderness Area. **Table 3–4** includes the monthly average temperatures and annual precipitation, including snowfall and snow depth, of representative areas in or near these climate regimes. **Table 3–5** includes monthly average snow depths for these stations as well.

3.1.2.1 *Southern Poker Flat Research Range Launch Corridor Climate Regime*

The climate in this region is similar to that of Fairbanks, Alaska, and is classified as “continental subarctic,” characterized by great seasonal extremes of temperature and daylight **(USFWS 2011c)**. In Fairbanks, from mid-May through the end of July, a period of 72 days, the sun is above the horizon from 18 to 22 hours each day, and the entire region never gets darker than civil twilight. Further north at Fort Yukon, the sun stays above the horizon for 31 consecutive days in June and July and the period of twilight lasts 86 days. In contrast, from late November through January, the period of daylight, including twilight, averages less than 5 hours per day **(Edwards 2011)**.



Note: To convert kilometers to miles, multiply by 0.6214.
Source: SAIC 2011.

Figure 3–1. Climate Stations Located in or Near the Poker Flat Research Range Launch Corridor

Table 3–4. Monthly Average Temperature, Precipitation, and Station Information at Climate Stations Located in or Near the Poker Flat Research Range Launch Corridor

	Barter Island	Kuparuk	Toolik Lake	Atigun Pass	Arctic Village	Old Crow	Bettles	Fort Yukon	Fairbanks	Lake Chandalar
Temperature (Celsius)										
January	–26	–26	–23	–21	–31	–31	–23	–28	–22	–26
February	–29	–27	–21	–18	–28	–28	–21	–26	–19	–24
March	–27	–25	–21	–19	–19	–22	–15	–17	–11	–19
April	–18	–16	–13	–11	–10	–11	–5	–6	0	–9
May	–6	–5	–1	–1	3	3	7	7	10	3
June	1	5	9	5	12	12	15	15	16	12
July	4	9	12	7	14	14	15	17	17	13
August	4	7	8	3	9	11	11	13	13	9
September	0	2	0	–3	0	3	5	5	7	2
October	–9	–9	–12	–12	–12	–9	–7	–7	–4	–10
November	–18	–19	–19	–17	–24	–23	–18	–21	–16	–21
December	–24	–23	–22	–18	–24	–27	–21	–27	–20	–23
Annual Average	–12	–10	–4	–9	–9	–9	–5	–6	–2	–8
Annual Precipitation (centimeters)										
Total[a]	15	10	–	61	23	28	38	18	27	21
Snowfall	107	84	–	–	124	130	230	107	170	120
Station Information										
Station Elevation (meters)	9	20	720	1,400	640	250	200	130	130	580
Period	1949–1988	1980–2010	1989–2007	1992–2009	1962–1996	1971–2000	1980–2010	1938–1990	1981–2010	1981–2010

a. Total precipitation per year is sum of rain and snow water equivalent.

Note: To convert centimeters to inches, multiply by 0.3937; meters to feet, by 3.2808; Celsius to Fahrenheit, use the formula (5/9) × (T Fahrenheit) – 32.

Key: –=missing data.

Source: Environment Canada 2011; NCDC 2011a; USFWS 2011c.

Table 3–5. Monthly Average Snow Depth for Climate Stations Located in or Near the Poker Flat Research Range Launch Corridor

	Barter Island	Kuparuk	Toolik Lake	Atigun Pass[a]	Arctic Village	Old Crow[b]	Bettles	Fort Yukon	Fairbanks	Lake Chandalar
Average Snow Depth (centimeters)										
January	31	20	–	18	43	48	64	48	43	48
February	36	20	–	18	43	56	74	56	53	58
March	36	23	–	20	53	59	79	58	51	56
April	38	23	–	10	53	55	66	41	25	56
May	25	13	–	3	15	17	10	5	0	18
June	3	0	–	0	0	0	0	0	0	0
July	0	0	–	0	0	0	0	0	0	0
August	0	0	–	0	0	0	0	0	0	0
September	3	0	–	0	3	5	0	0	0	0
October	13	8	–	10	10	13	10	5	5	10
November	20	15	–	13	23	26	31	23	20	25
December	25	18	–	13	33	36	51	36	33	36
Station Information										
Station Elevation (meters)	9	20	720	1,400	640	250	190	130	130	580
Period	1949–1988	1983–2010	1989–2007	1970–1980	1962–1996	1971–2000	1951–2010	1938–1990	1949–2010	1968–2010

a. Snow depth from Galbraith Lake Camp, located 13 kilometers (8 miles) northeast of Atigun Pass.

b. Snow depth estimated from monthly average snowfall and average temperatures.

Note: To convert centimeters to inches, multiply by 0.3937; meters to feet, by 3.2808.

Key: –=missing data.

Source: WRCC 2011.

During summer, daily average maximum temperatures reach the lower 20s in degrees Celsius (°C) (70 degrees Fahrenheit [°F]). Temperatures of 27 °C (80 °F) or higher occur on about 10 days each summer, and temperatures in the mid-30s °C (90 °F) have been recorded at Fairbanks on several occasions **(NCDC 2011a)**. Fort Yukon holds the state record high temperature of 38 °C (100 °F) **(USFWS 2008a)**. Average temperatures for July range from 17 °C (62 °F) in Fairbanks to 13 °C (55 °F) further north at Lake Chandalar **(NCDC 2011a)**. Precipitation averages around 27 centimeters (11 inches) for the year, with the majority of the precipitation falling in the summer months. With the exception of the highest elevations on the northern end of the region, winter snows have melted by the end of April, and river ice breakups occur in May **(NCDC 2011b)**. However, due to the combination of snowmelt and partial melting of the permafrost, the soils remain very wet throughout the summer.

Average temperatures across the entire region in winter are below –17 °C (0 °F), and temperatures of –40 °C (–40 °F) or colder are common. Fort Yukon has recorded a temperature as low as –59 °C (–75 °F). Average temperatures in January range from –22 °C (–9 °F) at Fairbanks to –28 °C (–19 °F) at Fort Yukon. Snow covers the ground from early October through April, with the maximum average monthly snow depth occurring in March, ranging from 53 centimeters (21 inches) in Fairbanks to near 80 centimeters (31 inches) in Bettles. However, winds are light most of the winter and blizzard conditions are rarely seen **(NCDC 2011b)**.

3.1.2.2 *Central Poker Flat Research Range Launch Corridor Climate Regime*

The climate in this region is also classified as “continental subarctic,” but with colder temperatures in both the winter and the summer as compared to the climate in the southern launch corridor. Summer daylight is longer, with approximately 53 days of continuous sunlight and twilight lasting 97 days. The winter is darker than the southern PFRR launch corridor climate regime, with the sun below the horizon for 27 days in December and January and twilight reduced to approximately 4 hours per day during this time **(Edwards 2011)**.

Summer temperatures can vary greatly between the higher elevations in Brooks Range and the valley floors. Average temperatures in July are only about 7 °C (44 °F) at Atigun Pass (elevation 1,400 meters [4,600 feet]), but climb to 14 °C (58 °F) at Arctic Village (elevation 640 meters [2,100 feet]) **(USFWS 2011c)**. With the colder temperatures and more mountainous terrain, winter snows are deeper and may not completely melt in the highest elevations in the summer. In the valleys and foothills, the snow generally melts by mid-May, and river ice breakup occurs in late May or early June. The climate is dry, with average annual precipitation ranging from around 25 centimeters (10 inches) in the lower elevations to as high as 66 centimeters (26 inches) in the mountainous regions, with the majority of the precipitation falling in the summer months as rain. However, steeper slopes and warmer temperatures in Brooks Range provide enhanced drainage for soils and drier habitats during the summer. However, the snowmelt over the continuous permafrost in this climate region results in wetland-type conditions in the valley regions from June through September **(USFWS 2011c)**.

Winter temperatures can be bitterly cold throughout the region, but particularly in the lower elevations, where clear skies and light winds allow temperatures to plummet. Average temperatures in January range from –21 °C (–5 °F) in the mountainous regions (Atigun Pass) to

–31 °C (–24 °F) near Old Crow just on the Canadian side of Brooks Range. Maximum monthly average snow depth is from 53–59 centimeters (21–24 inches) and occurs in March around Old Crow and Arctic Village **(WRCC 2011)**. However, much higher snow depths occur in the higher elevations of Brooks Range. Overall, the climate is dry, with average annual precipitation ranging from around 25 centimeters (10 inches) in the lower elevations to as high as 66 centimeters (26 inches) in the mountainous regions, with the majority of the precipitation falling in the summer months as rain.

3.1.2.3 *Northern Poker Flat Research Range Launch Corridor Climate Regime*

The climate in this region is classified as "Arctic" and is characterized by short, cool summers and long, cold winters with subfreezing temperatures and snow possible year round **(USFWS 2011c)**. The close proximity of this region to the Bering Sea results in a climate that is tempered somewhat and is not subject to the extreme temperature variations found in the southern and central launch corridor regions. Summer daylight is long, with approximately 72 days of continuous sunlight and twilight lasting 110 days. The winter is dark, with the sun below the horizon for 27 days in December and January and twilight reduced to approximately 4 hours per day during this time **(Edwards 2011)**.

Summer temperatures are significantly impacted by the Bering Sea. Average temperatures in July are around 4 °C (40 °F) along the coast, warming to around 12 °C (53 °F) inland near Toolik Lake **(USFWS 2011c)**. With the exception of north-facing slopes of the Brooks Range Foothills, the winter snowcover melts away by early June. The climate is very dry, with only about 15 centimeters (6 inches) of precipitation falling annually, most of which falls in the summer as rain. Evaporation rates are low due to low temperatures throughout the year, and the land is underlain by continuously frozen soil. As a result, soils are usually saturated during the summer in the coastal plain **(USFWS 2011c)**.

Temperatures in winter are the coldest in February along the north coast, with averages around –29 °C (–20 °F), but are warmer at the higher elevations (Toolik Lake), averaging –23 °C (–10 °F) in January. The region is under snowcover from mid-September through May. The maximum monthly average snow depth is 38 centimeters (15 inches) in April at Barter Island **(WRCC 2011)**.

Surface winds along the coast generally average 15 to 24 kilometers (9 to 15 miles) per hour from the northeast, with occasional intense storms generating winds exceeding 113 kilometers (70 miles) per hour **(USFWS 2011c)**.

3.1.2.4 *Global Climate*

Carbon dioxide and other gases in the atmosphere act like glass in a greenhouse, letting the sun's rays through, but trapping some of the heat that would otherwise be radiated back into space **(NASA 2000a)**. This greenhouse effect and the Earth's radiation balance are affected largely by water vapor; carbon dioxide; and other trace gases, including nitrous oxide, halocarbons, and methane. Increases in atmospheric concentrations of these pollutants are believed to influence the Earth's global climate **(IPCC 2007)**. The Arctic is especially vulnerable to global climate change and increased ultraviolet radiation. The primary impacts are expected physical and biological changes. Changes that have been observed and changes that are expected are discussed in Chapters 6 through 9 of the *Arctic Climate Impact Assessment* **(ACIA 2004)**. Annual average temperatures have increased more rapidly in the Arctic than in other parts of the world. Warming of the Arctic climate has resulted in earlier spring snowmelt, reduced sea ice, widespread glacier retreat, insect outbreaks, permafrost warming, and changes in Arctic vegetation **(NOAA 2006a; USFWS 2011c)**.

From 2000 through 2005, worldwide use of fossil fuels was estimated to emit about 26.4 billion metric tons (29.1 billion tons) per year of carbon dioxide into the atmosphere **(IPCC 2007)**. Estimated U.S. carbon dioxide emissions in 2006 were 5.98 billion metric tons (6.59 billion tons) **(USEPA 2008)**. Annual carbon dioxide emissions and carbon dioxide equivalent emissions of other greenhouse gases related to activities at PFRR are estimated to be 2,100 metric tons (2,400 tons) per year.

3.2 ECOREGIONS

The ecoregion classification system, developed by **Gallant *et al.* (1995)**, was used as a spatial framework to organize, inventory, and characterize the ROI. This delineation of Alaska ecoregions was based on a qualitative assessment and synthesis of the distribution patterns and relative importance of landscape geography, geology, hydrology, soils, climate, and vegetation data. The system provides a unified approach for conducting natural resource and ecological risk assessments and environmental research, management, and monitoring. The ecoregions located within the PFRR launch corridor flight zones are listed in **Table 3–6** and are shown in **Figure 3–2**.

3.2.1 Beaufort Sea Ecoregion

The Beaufort Sea Ecoregion is the part of the Arctic Ocean that skirts the northernmost Arctic Coastal Plain Ecoregion and portions of the Arctic Foothills Ecoregion coastlines. Approximately 3 percent (330,000 hectares [820,000 acres]) of PFRR is within the Beaufort Sea Ecoregion (see Table 3–6 and Figure 3–2).

3.2.2 Arctic Coastal Plain Ecoregion

The Arctic Coastal Plain Ecoregion is a treeless, gently sloping plain and tundra gradually rising from the Beaufort Sea to the rolling plateaus and uplands of the Arctic Foothills Ecoregion and mountains of the Brooks Range Ecoregion. Approximately 2 percent (171,000 hectares [420,000 acres]) of PFRR is within the Arctic Coastal Plain Ecoregion (see Table 3–6 and Figure 3–2). Slope gradients are typically less than 2 percent **(Gallant *et al.* 1995)**.

Table 3–6. Poker Flat Research Range Flight Zones and Associated Ecoregions[a]

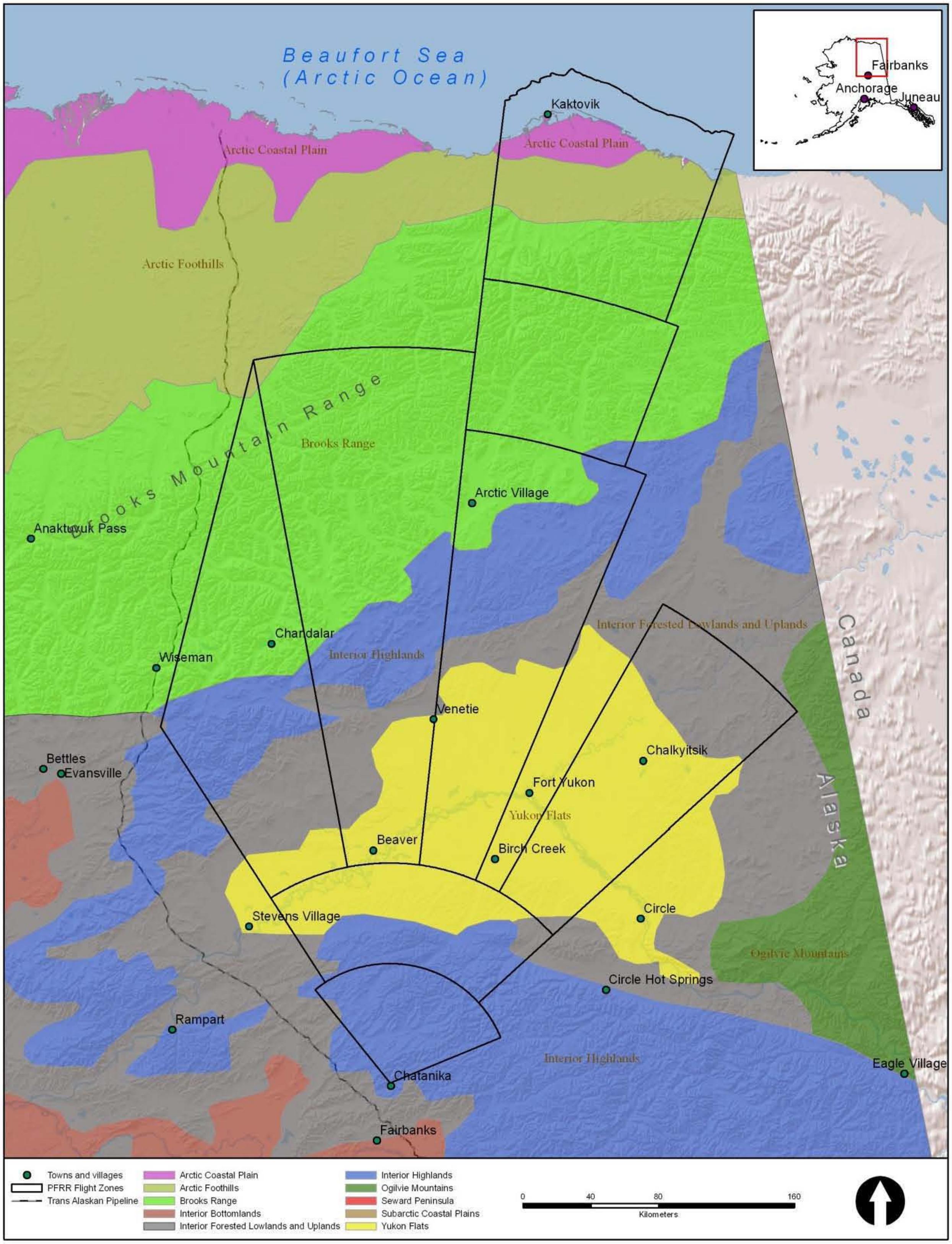
PFRR Flight Zones	Ecoregion Area (Ecoregion ID Number) (hectares)							Beaufort Sea	Total
	Arctic Coastal Plain (101)	Arctic Foothills (102)	Brooks Range (103)	Interior Forested Lowlands and Uplands (104)	Interior Highlands (105)	Yukon Flats (107)	Ogilvie Mountains (108)[b]		
1 South	0	0	0	5,200	460,000	0	0	0	460,000
1 North	0	0	0	61,000	350,000	420,000	0	0	830,000
2	0	9,000	770,000	370,000	410,000	130,000	0	0	1,700,000
3	0	14,000	1,600,000	290,000	430,000	300,000	0	0	2,600,000
4	0	0	340,000	250,000	610,000	650,000	0	0	1,900,000
4 Extended	0	0	930,000	0	26,000	0	0	0	957,054
4 Arctic Extension	171,000	440,000	540,000	0	0	0	0	330,000	1,500,000
5	0	0	0	500,000	0	900,000	18	0	1,400,000
Total	**171,000**	**470,000**	**4,200,000**	**1,500,000**	**2,300,000**	**2,400,000**	**18**	**330,000**	
Grand Total									**11,300,000**

a. Poker Flat Research Range flight zones and associated ecoregions are shown in Figure 3–3.

b. Due to the small amount of the Ogilvie Mountains Ecoregion within the region of influence, the Ogilvie Mountains Ecoregion is not discussed further in this *PFRR EIS*.

Note: To convert hectares to acres, multiply by 2.4710. Totals may not add up exactly due to rounding.

Source: Gallant *et al.* 1995.



Note: To convert kilometers to miles, multiply by 0.6214.
Source: SAIC 2011.

Figure 3–2. Poker Flat Research Range Ecoregions

3.2.3 Arctic Foothills Ecoregion

The Arctic Foothills Ecoregion is an area of broad, rounded ridges and plateau uplands (northern portion) and irregular buttes, mesas, ridges, and undulating tundra (southern portion) between the Arctic Coastal Plain Ecoregion and Brooks Range Ecoregion. East of the Kongakut River, the Arctic Foothills Ecoregion extends to the Beaufort Sea coast (see Figure 3–2). Approximately 4 percent (470,000 hectares [1.2 million acres]) of PFRR is within the Arctic Foothills Ecoregion (see Table 3–6 and Figure 3–2). This is described as a predominantly treeless region of moderately steep to steep hills and broad, sloping valleys and tundra **(USFWS 2011c)**.

3.2.4 Brooks Range Ecoregion

The Brooks Range Ecoregion, as the northernmost mountain group in Alaska, forms the drainage divide between the Arctic Slope to the north and the Kobuk and Yukon Rivers to the south. Mountains within the PFRR portion of the ecosystem include Phillip Smith, Franklin, Davidson, Sadlerochit, Shublik, and Romanzof Mountains **(Molnia 2008)**. Approximately 37 percent (4.2 million hectares [10 million acres]) of PFRR is within the Brooks Range Ecoregion (see Table 3–6 and Figure 3–2). The deeply dissected mountains have wide, flat-floored, steep-sided glacial alpine valleys **(USFWS 2011c)**. Mountain slopes are covered with exposed bedrock and rock debris and generally range from 10 to greater than 30 percent gradients. Elevations range from 500 meters (1,600 feet) in alpine valley floors to 2,400 meters (7,900 feet) at the higher mountain peaks.

3.2.5 Interior Forested Lowlands and Uplands Ecoregion

The Interior Forested Lowlands and Uplands Ecoregion is characterized by undulating lowlands, peat plateaus, and rolling hill uplands with slope gradients generally ranging from 0 to 10 percent **(Brabets *et al.* 2000)**. Approximately 13 percent (1.5 million hectares [3.6 million acres]) of PFRR is within the Interior Forested Lowlands and Uplands Ecoregion (see Table 3–6 and Figure 3–2). Elevations range from sea level to 700 meters (2,300 feet) for some of the higher hills.

3.2.6 Interior Highlands Ecoregion

The Interior Highlands Ecoregion is located between the Interior Forested Lowlands and Uplands Ecoregion and the Brooks Range Ecoregion. The Interior Highlands Ecoregion contains steep and rounded ridges, valleys, and low mountains with glaciated peaks that rise from approximately 1,500 meters (4,900 feet) to over 1,800 meters (5,900 feet) **(Gallant *et al.* 1995)**. Approximately 20 percent (2.3 million hectares [5.7 million acres]) of PFRR is within the Interior Highlands Ecoregion (see Table 3–6 and Figure 3–2). Slope gradients generally range from about 10 to greater than 30 percent **(Gallant *et al.* 1995)**.

3.2.7 Yukon Flats Ecoregion

The Yukon Flats Ecoregion is a relatively flat, marshy river basin characterized by numerous lakes, shallow ponds, sloughs, drainage basins, river meander scars, islands, river outwash fans, and braided stream floodplains surrounded by gently to strongly rolling terrain. Elevations range from 90 meters (300 feet) to greater than 250 meters (820 feet), and slope gradients are generally less than 2 percent. The Yukon Flats Ecoregion was not glaciated during the Pleistocene epoch **(Gallant *et al.* 1995)**. Approximately 21 percent (2.4 million hectares [5.9 million acres]) of PFRR is within the Yukon Flats Ecoregion (see Table 3–6 and Figure 3–2).

3.3 WATER RESOURCES

Surface waters typically include rivers, streams, bays, springs, lakes and ponds, and other wetlands. Groundwater includes the subsurface geohydrologic resources generally described as water tables and aquifers. The ROI for water resources is defined as the area within the PFRR launch site and launch corridor. Section 3.3.4 provides a description of the water resources within the ROI based on the ecoregions discussed in Section 3.2.

3.3.1 Wetlands, Floodplains and Coastal Zone

Wetlands are areas of transition between terrestrial and aquatic systems where the water table is usually at or near the surface. Wetlands are defined in the U.S. Army Corps of Engineers Wetlands Delineation Manual as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" **(USACE 1987)**. Wetlands are extremely common in Alaska; there are an estimated 71 million hectares (180 million acres) of wetlands, accounting for approximately 42 percent of the total surface area of the state **(ADEC 2010)**. In addition to permafrost areas, wetlands frequently occur within the riverine floodplains and can develop because of rainfall, melt water, beavers, and tides. In Alaska, melt water from snow and glaciers often causes streams to overflow their banks during spring and summer months. Ice jams, which may exacerbate flooding, are particularly common near the villages of Circle and Fort Yukon **(NOAA 2006b)**.

Within the PFRR launch site, much of the area in the Lower Range is designated as a palustrine wetland system composed primarily of scrub-shrub and forested class wetlands with saturated water regimes. Most areas facing north and northwest, downslope of the Upper Range ridgeline are also classified as wetlands. Details on wetlands at PFRR, including the associated vegetation, are given in the *Environmental Assessment, Improvement and Modernization Program, Poker Flat Research Range, Fairbanks, Alaska (Modernization EA),* published by the Geophysical Institute of UAF **(UAF 1993)**. Wetlands identified in the *Modernization EA* are listed in **Table 3–7**.

The Chatanika River originates north and east of the ROI and flows westward into the Tolovana River, which flows into the Tanana River. The main flood seasons are spring and summer. Spring floods are the result of an above-normal winter snowfall, coupled with a cold spring and a rapid snowmelt. Summer flooding results from extreme rainfall in a short period of time. The Lower Range of the PFRR launch site is located within the 100-year floodplain of the Chatanika River.

Table 3–7. Poker Flat Research Range Wetlands

Wetland	Description
Wet Graminoid Herbaceous	Vegetation is dominated by marsh five-finger, cottongrass, carex, and the sandbar willow.
Needleleaf Woodland	Consists predominantly of black spruce. The understory shrub includes Labrador tea, mountain carndary, cloudberry, and resin birch. The herbaceous stratum is predominantly clubmoss, but the lichen layer is prominent in open areas.
Mixed Woodland	Includes paper birch and black spruce. The understory is dominated by Labrador tea, bog blueberry, lowbush cranberry, spirea, and diamond-leaf willow. The herbaceous stratum is predominantly feathermoss. Lichen is prominent in open area. Also present are cottongrass, bluejoint, and horsetail.
Needleleaf Forest	Dominated by black spruce. Paper birch is also present. The understory consists of Labrador tea, lowbush cranberry, bog blueberry, and spirea. The herbaceous matt is thick with moss and lichens.
Closed Birch Forest	Dominated by paper birch, with small components of black spruce. The understory consists of Labrador tea, cranberry, and moss matt.
Mixed Forest	Dominated by quaking aspen, white spruce, and paper birch. The understory consists of bluejoint, Pyrola, and rose.
Closed Tall Scrub Shrub	Dominated by a dense canopy of green alder; however, paper birch and aspen are also present. Understory consists of raspberry and bluejoint.
Closed Broadleaf Forest	Dominated by paper birch, with scattering of quaking aspen and white spruce. In understory, green alder, lowbush cranberry, bog blueberry, fireweed, and bluejoint are common.

Source: NASA 2000a; UAF 1993.

The Coastal Zone Management Act (CZMA) of 1972, as amended **(16 U.S.C. 1451 *et seq.*)**, provides for the effective, beneficial use, protection, and development of the U.S. coastal zone. Section 307 of the CZMA requires Federal agencies conducting activities that potentially impact coastal zones to be consistent, to the maximum extent practicable, with the approved coastal management program of the respective state within which the activity would occur. The coastal zone is defined as coastal waters and adjacent shore lands strongly influenced by each other and in proximity to the several coastal states, including islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The Alaska Coastal Management Program was terminated on July 1, 2011, per **Alaska Statute 44.66.030**. Prior to its termination, NASA contacted the Alaska Coastal Management Program in April 2011 and was informed that a consistency determination would not be required for the alternatives under consideration in this EIS. Therefore, no additional coordination regarding coastal zone management is needed.

3.3.2 Wild and Scenic Rivers

The National Wild and Scenic Rivers System, established in 1968 by the Wild and Scenic Rivers Act **(P.L. 90–542)** and administered by the National Park Service (NPS), was created to enhance and protect the free-flowing condition; water quality; and remarkable natural, cultural, and recreational values and to fulfill the vital conservation of designated rivers and streams **(IWSRCC 1998)**. Alaska National Interest Lands Conservation Act (ANILCA) provides for the designation and conservation of public lands in the State of Alaska. In Alaska, designated wild river segment corridors outside Federal lands may not exceed an average of 259 hectares (640 acres) (0.8 kilometers [0.5 mile] from each river bank) per river mile. Corridor boundaries are established based on natural and manmade features and existing property lines. Within Federal lands, no new mining claims or mineral leases can be granted within designated wild river segments; however, existing mining claims and leases within designated river corridor boundaries remain in effect. River designation under the Wild Scenic River Act neither gives nor implies government control of private lands within the river corridor **(IWSRCC 2004, 2011)**. Designated wild rivers are to be maintained in natural, free-flowing, and undisturbed conditions. River segments added to the National Wild and Scenic Rivers System by ANILCA located within the PFFR launch corridor are shown in red on Figure 1–3 and summarized below in **Table 3–8**.

Table 3–8. Poker Flat Research Range National Wild and Scenic River Segments

Water Course	Description
Beaver Creek	The Beaver Creek watershed is located within the Yukon-Tanana uplands of the east-central Alaska interior. Approximately 216 kilometers of the upper portion Beaver Creek has been designated as a wild river. The moderately swift and shallow stream originates at the confluence of Bear and Champion Creeks of the White Mountains and flows approximately 430 kilometers to its confluence with the Yukon River. Once within the lowlands of the Yukon Flats, it is characterized as a sluggish meandering stream. Discharges from numerous springs contribute significantly to winter streamflow. Designated wild portions of Beaver Creek are located in the White Mountains NRA (133 kilometers) and Yukon Flats NWR (32 kilometers) and within PFRR.
Ivishak River	The Ivishak River originates in the Philip Smith Mountains and flows northward, where it merges with the Sagavanirktok south of Prudhoe Bay. Once in the Arctic Coastal Plain, the waterway is characterized as a low-gradient, braided stream with a broad floodplain. Of the total 180 kilometers of the Ivishak River, 96 kilometers of designated wild river flow through the Arctic NWR within PFRR. The designated wild portion of the river basin within PFRR encompasses approximately 80,000 hectares and 7,300 hectares outside of PFRR.
Sheenjek River	The Sheenjek River is a subbasin watershed of the Porcupine Basin and encompasses a drainage area of approximately 58,000 hectares. This water course originates in Brooks Range and merges with the Porcupine River near Fort Yukon. The upper segment of the river is within Arctic NWR and the lower segment flows through Yukon Flats NWR. Approximately 270 kilometers of the river have been designated as wild. The portion of the Sheenjek River that flows through Arctic NWR, including Mollie Beattie Wilderness Area within Arctic NWR (203 kilometers), is designated as wild and is located within PFRR. No portion of the Sheenjek River that flows through Yukon Flats NWR is designated as wild or scenic. This pristine low-gradient river meanders primarily through broad mountain valley tundra and is characterized by clear water, cutbanks, and gravel streambeds.

Table 3–8. Poker Flat Research Range National Wild and Scenic River Segments (*continued*)

Water Course	Description
Wind River	The Wind River originates in the Philip Smith Mountains and flows approximately 180 kilometers. The river basin covers approximately 79,000 hectares. The entire river (180 kilometers) is designated wild and is located within Arctic NWR and PFRR.

Note: To convert hectares to acres, multiply by 2.4710; kilometers to miles, multiply by 0.6214; square kilometers to square miles, multiply by 0.3861.
Key: NRA=National Recreation Area; NWR=National Wildlife Refuge; PFRR=Poker Flat Research Range.
Source: Brabets *et al.* 2000; Kostohrys 2005; Maurer 1997; Meyer 1995; USDOI 1983; USFWS 2011c.

3.3.3 Water Quality

Water quality is a measure of the physical, chemical, and/or biological characteristics of water compared with established standards. Water quality is considered impaired if it fails to meet physical, chemical, and/or biological or regulatory standards. The Clean Water Act of 1977, as amended (CWA) **(33 U.S.C. 1251 *et seq.*)**, regulates pollutant discharges. As authorized by CWA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The NPDES permit program is administered by the State of Alaska through the Alaska Department of Environmental Conservation (ADEC).

CWA requires individual states to develop programs to monitor and report on the quality of surface water and groundwater and prepare a report summarizing the status of its water quality. CWA Section 305(b) requires that the quality of all water bodies be characterized and Section 303(d) requires states to establish water quality standards for waterways, identify those that fail to meet the standards, and take action to clean up these waterways. Water quality standards are composed of designated present and future most beneficial uses and numerical and narrative criteria applied to the specific water uses or classification. Water bodies verified as not meeting one or more of their designated uses are placed on the state's 303(d) list, and a Total Maximum Daily Load (TMDL) or recovery plan is developed by the state to address water quality impairment issues **(ADEC 2010)**.

The state of Alaska has jurisdiction for surface-water quality standards for all waters of the state, in accordance with CWA provisions. The ADEC Division of Water is responsible for establishing water cleanliness standards, regulating discharges into water of the state, and monitoring and reporting on water quality. The State of Alaska Water Quality Standards are documented in the Alaska Administrative Code **(18 AAC 70)** and in an annual report. Alaska's 305(b) and 303(d) water quality data are combined and presented as an Integrated Water Quality Monitoring and Assessment Report that documents the status and health of water bodies within the state and identifies programs for maintaining and improving water quality. Alaska has 28 Category 5 303(d) listed water bodies with one or more designated uses not attained that require a TMDL or recovery plan **(ADEC 2010)**.

The overall water quality in Alaska is generally good to excellent. The state contains vast areas, such as those that comprise a major portion of PFRR, that are in pristine condition and are charactereized by excellent water quality. Yukon River water quality ranges from good to excellent. Except for seasonal turbidity, the river generally has low dissolved solids, near saturation dissolved oxygen, and neutral to moderately basic pH **(USDOI 2012a)**. Turbidity is a suspension of dissolved substances and inorganic and organic particles in the water column that results in the scattering and absorption of sunlight **(Henley *et al.* 2000)**. A water resource field reconnaissance of the eastern north slope in 1975 found that with few exceptions, water body water quality was generally very good **(Childers *et al.* 1977)**. There are limited water resource water quality data available for much of the Arctic North Slope and South Slope below Brooks Range **(USFWS 2011c)**. A summary of water quality parameters for select rivers within PFRR is presented in **Table 3–9**.

Table 3–9. Poker Flat Research Range Water Quality

River	Water Temperature (degrees Celsius)	pH (Standard Units)	Dissolved Oxygen (milligrams per liter)
Beaver Creek (at Big Bend)	10	7.3	11
Birch Creek (Upper Mouth)	14	7.5	9.2
Black River	13	7.7	9.5
Chandalar River	10	7.9	11
Hodzana River	11	7.7	9.8
Porcupine River	10	7.7	10
Yukon River (at Eagle)	13	8.1	9.6
Alaska Department of Environmental Conservation Standard	**Less than 15**	**6.0 to 8.5**	**Greater than 4.0**

Note: To convert Celsius to Fahrenheit, use the formula (5/9) × (T Fahrenheit) – 32.
Source: USDOI 2012a.

The Category 5 Section 303(d) listed water bodies within PFRR are contained in the Crooked Creek Watershed (Hydrologic Unit Code 19040402) and include Crooked, Bonanza, Deadwood, Ketchem, Mammoth, Mastodon, and Porcupine Creeks. The watershed was 303(d) listed in 1992 for nonattainment of turbidity standards **(ADEC 2010)**. The primary pollutant source was placer mining. Monitoring in the 1990s and a water quality assessment in 1995 documented water quality improvements and recommended the development of a water body recovery plan. ADEC is preparing a water quality monitoring and sampling plan for 2011 and 2012 to determine if a TMDL is required **(ADEC 2010)**.

3.3.4 Ecoregions

This section describes the water resources within the ROI based on the ecoregion descriptions provided in Section 3.2.

3.3.4.1 *Beaufort Sea Ecoregion*

The approximate area of ocean inland seas (bays and lagoons) within Beaufort Sea Ecoregion of the ROI is 9,100 hectares (22,000 acres). Coastal currents are driven by inflows from the Bering Strait, Beaufort Gyre, and intermediate water from the North Atlantic. Tide action is relatively minor, with a diurnal range of 10 to 30 centimeters (4 to 12 inches) **(ADNR 2006; USFWS 2011c)**. Storm surges (storm increases in sea elevation) can reach approximately 2.4 meters (8 feet) during severe storms **(ADNR 2006)**. Coastal lagoon waters begin to freeze in late September to early October and by April or May, the ice may be 2 meters (6 feet) or more thick. Approximately 40,000 hectares (100,000 acres) of the Beaufort Sea Ecoregion marine coast waters and lagoons within Arctic NWR are designated as marine protected areas under the auspices of the National Marine Protected Area System **(USFWS 2011c)**.

A defining characteristic feature of the Beaufort Sea is its cover of sea ice, which seasonally fluctuates in extent and thickness on interannual and long-term temporal scales. The sea ice cover generally includes a perennial ice zone where ice is present year-round, and a zone where ice is only present seasonally; much of the Arctic Ocean is considered perennial ice **(Kwok and Sulsky 2010)**. The maximum extent of Arctic sea ice cover is achieved by the end of winter, and the minimum extent occurs in September **(Wendler *et al.* 2010)**. For most of the year, ice covers the Beaufort Sea **(USDOI 1978)**. Typically, the breakup of coastal sea ice begins 8 weeks after melt processes begin **(USFWS 2011c)**.

Sea ice ranges from first-year, non-deformed ice to multi-year ice with thick, deformed, pressure ridges. Sea ice moves in response to wind and ocean currents and deforms due to fractures and cracks created by brittle failure. The mechanical movement and rearrangement of the ice directly affect its strength and behavior **(Kwok and Sulsky 2010)**. In contrast to the migrating ice packs of the distant Arctic Ocean, landfast ice is relatively immobile sea ice that is anchored to nearshore environments due to the sporadic contact of the ice with the sea floor **(Fissel *et al.* 2011)**. Sea ice is typically covered with snow for most of the year, except for when new ice forms and during the short Arctic summer. Because of its age, multi-year ice generally has deeper snow cover than first-year ice. Rougher-surfaced ice also tends to accumulate more snow cover **(Sturm *et al.* 2006)**.

Sea ice concentration (SIC) is the area of the ocean covered by ice **(Stone 2010)** and sea ice extent is the region of the ocean containing at least 15 percent SIC. SIC in seasonal zones varies dramatically, particularly along the southern sea ice margins **(Wendler *et al.* 2010)**. Seasonal fluctuations in the development, migration, and decay of sea ice are generally governed by the movement of the polar ice pack along the coastline and activity of major rivers **(USDOI 1978)**. In the Beaufort Sea, the average SIC is lowest from August through October **(Stone 2010)**.

The thickness of sea ice varies dramatically in temporal and spatial terms. In addition to thermodynamic forcing, research suggests that variations in Arctic ice thickness are strongly influenced by ocean and wind dynamic mechanical forcing **(Laxon *et al.* 2003)**. The discontinuous motion and behavior of ice influences it thickness distribution (**Kwok and Sulsky 2010)**. For the Arctic Ocean, the maximum thickness is generally cited as approximately 3 meters (10 feet). Typically, non-deformed first-year ice is as much as 2 meters (7 feet) thick and mulit-year ice is greater than 2 meters thick. Ice that has been deformed and exhibits ridge formation may be as thick as 20 to 30 meters (66 to 98 feet) **(Wendler *et al.* 2010)**. Southern Beaufort Sea ice thickness was observed to average 2.5 meters (8.2 feet) with variability ranging up to 2.7 meters (8.9 feet) **(Laxon *et al.* 2003)**. The thickness of landfast ice is primarily dependent on air temperature and snow cover **(Fissel *et al.* 2011)**.

A study by **Oikkonen and Haapala (2011)** found that Arctic sea ice has generally shifted toward thinner ice and exhibits a prevalent loss of thick, deformed ice. Although offshore regions of the Arctic pack ice are experiencing reduction in ice thickness associated with the net loss of old ice, shelf areas of the Southern Beaufort Sea dominated by highly deformed first-year ice exhibited no reductions in thickness for the years 2008 and 2009 **(Fissel *et al.* 2011)**. For the 1960s, 1970s, and 1990s there was a 1.3-meter (4.3-foot) decrease in the average thickness of Beaufort Sea ice **(Laxon *et al.* 2003)**.

Arctic ice has undergone a dramatic decline over recent years, with a well-documented general ice thinning, retreat of summer sea ice cover, and transition to a younger ice pack. Contributing factors include changes in atmospheric variables (temperature, circulation, and cloudiness), increased ice export and redistribution, storm events, and increased solar heating of the upper ocean **(Perovich *et al.* 2011; Wendler *et al.* 2010)**. The Northern Hemisphere's sea ice has been declining at an average rate of 3 percent per decade (1978 to present) and summer declines appear to be accelerating. The loss of old, multi-year ice is occurring at a higher rate of approximately 10 percent per decade; greater than two-thirds of the Arctic is currently covered by thinner seasonal ice **(Kwok and Sulsky 2010)**. From 1979 to 2005 the extent of Arctic Ocean sea ice decreased 9.2 percent per decade; the lowest extent being recorded in 2007 **(USFWS 2011c)**. From 2005 to 2009, multi-year ice decreased by a net 40 percent in volume while first-year ice gained volume due to the overall increased area covered **(Kwok and Sulsky 2010)**. A study of the Southern Beaufort Sea observed an increase in the mean annual area of open water from 14 percent in 1972 to 39 percent in 2007 **(Wendler *et al.* 2010)**. The floating ice pack is a critical component of the Arctic Ocean habitats and biological ecosystems. Changes in the extent and concentration of sea ice can directly affect the biological support capabilities of these systems **(Lindsay and Zhan 2005)**.

3.3.4.2 *Arctic Coastal Plain Ecoregion*

Prominent marine features within the Arctic Coastal Plain Ecoregion include shoals, mudflats, spits, shallow lagoons with low-lying barrier islands, bays, and river deltas **(USDOI 1978; USFWS 2011c)**. The coastline is low-lying and irregularly shaped and is dominated by low but steep coastal bluffs that typically range from 1.2 to 1.5 meters (4 to 5 feet) high, but in some instances may be as high as 7.6 meters (25 feet); in some cases, these bluffs are under active retreat **(Trawicki *et al.* 1991; USDOI 1978)**.

Recent increases in prevailing temperatures and storm frequency and reduced amounts of summer sea ice have created conditions amenable to increased coastal erosion **(USFWS 2011c)**. In some areas, the coastal bluffs are retreating as a result of thermal- and wave-induced erosion of permafrost soils **(USDOI 1978)**. Based on localized conditions, erosion rates vary from approximately 12 to 3 meters per year (38 to 10 feet per year) **(USFWS 2011c)**. **Wang and Overland (2009)** predicted drastic reductions in Arctic winter and summer ice over the next 30 years.

Water courses in the PFRR portion of the Arctic Coastal Plain Ecoregion tend to be low-gradient, braided, distributary systems that are classified as mountain, spring, and tundra streams **(Gallant *et al.* 1995; Greenwald *et at.* 2008; Schickhoff *et al.* 2002)**. Mountain streams normally have coarse gravel bottoms and transport discharge from springs and surface runoff. Spring streams are fed by mountain springs and are characterized by relatively stable temperatures and discharge volumes that allow channels to remain unfrozen through winter **(Parker 2004)**. Mountain and spring-fed streams have headwaters in Brooks Range. Tundra streams primarily drain the Arctic Coastal Plain Ecoregion and Arctic Foothills Ecoregion and are classified as alluvial, riffle-pool sequence streams or peat-bottom streams with beaded channel morphology **(Greenwald *et at.* 2008; Parker 2004)**. Groundwater seepage through taliks is a major contributor to stream flows **(Greenwald *et at.* 2008)**. Major Arctic Coastal Plain Ecoregion rivers intersecting PFRR include the Hulahula, Jago, Okerokovik, and Okpilak Rivers **(Childers *et al.* 1977)**.

The gentle slopes, poor drainage, perched water tables, and treeless landscape of the Arctic Coastal Plain Ecoregion often create wind-oriented thaw lakes and ponds particularly in river deltas. The melting of ground ice creates subsidence depressions that collect runoff. These relatively shallow (typically less than 1 meter [3 feet]); flat-bottom features most often have muck bottoms and freeze during winter. These generally impermanent surface features tend to follow dynamic annual cycles of development, expansion, drainage, and revegetation **(ADNR 2006; Gallant *et al.* 1995)**. The development of taliks beneath the lakes may contribute to their drainage in winter **(Riordan 2005)**. Most lakes within the Arctic Coastal Plain Ecoregion within the ROI are located within the Hulahula and Jago River deltas **(USFWS 2011c)**. In continuous permafrost areas, sources of groundwater are primarily concentrated within the unfrozen alluvium of thaw lakes and river deltas; however, the water is normally brackish or saline in bedrock beneath the permafrost **(Williams 1970)**.

3.3.4.3 *Arctic Foothills Ecoregion*

The Arctic Foothills Ecoregion is dissected by numerous beaded and meandering streams and partly braided rivers **(Schickhoff *et al.* 2002)**. Most streams originate in the mountains of the Brooks Range Ecoregion, derive their flow primarily from runoff, are underlain with permafrost, freeze during winter and flow approximately 5 months of the year north toward the Beaufort Sea within channels confined to bedrock catchments **(Gallant *et al.* 1995; Parker 2004)**. Most streambeds are lined with extremely course materials that include gravel, cobbles, and boulders **(Childers *et al.* 1977)**. Minor river flows caused by springs during winter create accumulations of icings or aufeis (overflow river ice) **(ADNR 2006)**. Even during the coldest winters, some groundwater continues to flow **(Hall 1979)**. Flooding and channel migration are common during spring melt, ice jams, and ice breakup **(Gallant *et al.* 1995)**. Major Arctic Foothills Ecoregion rivers within the ROI include the Aichilik, Ekaluakat, Egakstak, and Kongakut Rivers **(Childers *et al.* 1977)**. Lakes occur infrequently within the region and exist primarily as muck bottom, oxbow lakes within major river valleys **(Gallant *et al.* 1995)**.

3.3.4.4 *Brooks Range Ecoregion*

The Brooks Range Ecoregion, as the northernmost mountain group in Alaska, forms the drainage divide between the Arctic Slope to the north and the Kobuk and Yukon Rivers to the south.

Stream systems typically exhibit a trellis drainage pattern, with major rivers draining north and south and feeder tributaries draining east and west **(Gallant *et al.* 1995)**. Although infrequent, heavy summer rains in the mountains can trigger river peak flows and flooding **(ADNR 2006)**. Major Brooks Range Ecoregion rivers intersecting PFRR include the Canning, East Fork, Junjik, Kavik, Middle Fork, North Fork, Sheenjek, and Wind Rivers **(Childers *et al.* 1977)**. Although heavily glaciated, mountains lakes such as the Neruokpuk Lakes in the Hulahula River Basin and Lake Schrader occur infrequently but are prominent features **(USFWS 2011c)**. Most lakes occur in the rock basins of glaciated valleys, moraine areas, and river valley floodplains **(Gallant *et al.* 1995)**. The source of groundwater of the Brooks Range Ecoregion within the ROI is perennial springs associated with limestone faults **(Williams 1970)**.

3.3.4.5 *Interior Forested Lowlands and Uplands Ecoregion*

Major Interior Forested Lowlands and Uplands Ecoregion rivers intersecting PFRR include the Black, Chandalar, Christian, East Fork, Koness, Middle Fork, North Fork, Porcupine, Sheenjek, and Wind Rivers **(Childers *et al.* 1977; Daum and Troyer 1992)**. Thaw and oxbow lakes occur in the region but are not prominent features **(Gallant *et al.* 1995)**. In discontinuous permafrost areas, groundwater may occur in shallow talik-layer aquifers above the permafrost **(Williams 1970)**.

3.3.4.6 *Interior Highlands Ecoregion*

Water courses in the Interior Highlands Ecoregion tend to exhibit peak flows following the spring snowmelt, but moderate flows during the summer **(USFWS 2011c)**. Major Interior Highlands Ecoregion rivers within the ROI include the Chandalar, Christian, East Fork, Koness, Middle Fork, North Fork, Sheenjek, and Wind Rivers **(Childers *et al.* 1977; Daum and Troyer 1992)**. The approximately 2,100 hectares (5,200 acres) of the PFRR launch site are located in the Interior Highlands Ecoregion directly south of the Chatanika River in Chatanika, Alaska (see Figure 3–2). Facility flooding occurs infrequently and is minor in extent. The short-term flooding that does occur is normally associated with spring breakup when the ground is still frozen. The affected area is approximately 0.2 hectares (0.5 acres) in size and includes an area near the old Poker Inn and the field next to the C-Band Radar; flood waters persist for about a week.

3.3.4.7 *Yukon Flats Ecoregion*

The Yukon Flats Ecoregion is a relatively flat, marshy river basin characterized by numerous lakes, shallow ponds, sloughs, drainage basins, river meander scars, islands, river outwash fans, and braided stream floodplains surrounded by gently to strongly rolling terrain. The drainage patterns of the Yukon Flats Ecoregion generally follow a cyclic annual pattern of freeze-up; reduced winter base flow conditions; ice breakup spawning spring ice jams, scouring, and flooding of rivers and tributaries; and summer flows governed by precipitation, drought, and groundwater seepage. River and lake ice play a significant role in the hydrologic character of the region **(Woodward and Beever 2011)**. In addition to the Yukon River, there are approximately 11,000 kilometers (6,800 miles) of tributary streams and over 20,000 lakes and ponds within the Yukon Flats Ecoregion **(Woodward and Beever 2011)**. The area is drained by the Yukon River, which exhibits both meandering and braided stream flow patterns. A diversity of meandering stream tributaries flowing through the flats drains the surrounding uplands and mountainous regions. Major Yukon Flats Ecoregion streams and rivers within the ROI include Beaver and Birch Creeks and the Chandalar, Hodzana, Porcupine, and Yukon Rivers **(Brabets *et al.* 2000)**.

Lakes are an abundant and important component of the Yukon Flats Ecoregion ecosystems. Lakes were created primarily by the meandering of the Yukon River and its tributaries (oxbow lakes), accumulation of water within basins, beaver activity, and thermokarst development. Lakes have both closed and open drainage outlets and are frequently in contact with groundwater **(Heglund and Jones 2003)**. The Yukon Flats Ecoregion has an estimated lake area of 1,100 square kilometers (420 square miles) and lake density of 1 lake per 2 square kilometers (0.8 square miles) **(Arp and Jones 2009)**. A study by **Heglund and Jones (2003)** of 129 shallow riverine Yukon Flats Ecoregion lakes found that most were nearly circular in configuration and had depths that generally ranged from less than 0.5 meters (1.6 feet) to 6 meters (20 feet), with most lakes averaging less than 2 meters (7 feet).

3.4 GEOLOGY AND SOILS

Physical geography is defined by surface terrain patterns, forms, features, and hypsology (*i.e.,* study of the relative altitude of places). Geologic resources are consolidated or unconsolidated earth materials, including ore and aggregate materials, fossil fuels, and significant landforms. Soils are natural bodies of solids (minerals and organic matter), gases, and liquids occupying the Earth's surface that have distinguishable layers and/or the ability to support rooted plants **(USDA 2010)**. The ROI for geology and soils is defined as the area within the PFRR launch site and launch corridor. Section 3.4.5 provides a description of the geology and soils within the ROI based on the ecoregions discussed in Section 3.2.

3.4.1 Permafrost

Permafrost is Arctic or subarctic region earth material (soil, rock, ice, and organic matter) that experiences continuous temperatures at or below 0 °C (32 °F) for 2 or more years; it is perennially frozen, rather than permanently frozen ground **(French 2007; USDA 2004)**. Permafrost typically exists in multiple layers that vary in thickness from a few centimeters to several hundred meters **(Williams 1970)**. Permafrost terrain contains three distinct layers (see **Figure 3–3**): (1) the *active layer* is the uppermost layer of soil from the surface to the top of the frozen ground, which experiences seasonal freezing and thawing; (2) the perennially frozen *permafrost layer* that extends from the base of the active layer to the soil layer where temperatures exceed 0 °C (32 °F); and (3) the *talik layer* of unfrozen soil typically between the active layer and permafrost layer **(Osterkamp and Jorgenson 2009)**. Most of the hydrological, biological, and biochemical activity occurs in the active layer, which may range from several meters to a few centimeters deep. Based primarily on the extent of soil ice content, the permafrost layer may be completely impervious or semi-permeable **(Hinkel and Nelson 2003; Riordan 2005)**. Permafrost may contain water with elevated salinity or oil seep hydrocarbons, which prevents hard freezing **(Clough *et al.* 1987)**. Taliks tend to form beneath water bodies that do not freeze in winter **(Riordan 2005)**. In Alaska, freezing soil temperatures have been observed to depths greater than 305 meters (1,000 feet) **(Clough *et al.* 1987; Ray 1950)**.

Approximately 75 to 80 percent of Alaska is underlain with permafrost **(Osterkamp and Jorgenson 2009)**.

The landscape extent and distribution of permafrost is defined as continuous, discontinuous, and sporadic. *Continuous permafrost* designates areas where permafrost occurs uninterrupted and is normally colder than –6 °C (21 °F) **(Osterkamp and Jorgenson 2009; Ray 1950)**. Shallow lakes and rivers within these areas freeze to the bottom and are underlain with permafrost **(Hall 1979; USFWS 2011c)**. *Discontinuous permafrost* regions have scattered areas free of permafrost **(Osterkamp and Jorgenson 2009; Ray 1950; USFWS 2010)**. Temperatures range from a fraction of a degree below freezing to –2 °C (28 °F) **(Ping *et al.* 2004)**. *Sporadic permafrost* regions exhibit isolated areas of permafrost within thawed ground **(Osterkamp and Jorgenson 2009)**. Continuous permafrost dominates Arctic regions, while discontinuous and sporadic permafrost is primarily found in subarctic regions **(Riordan 2005)**. No sporadic permafrost was identified within PFRR. Permafrost within PFRR is summarized in **Table 3–10** and shown in Figure 3–3.

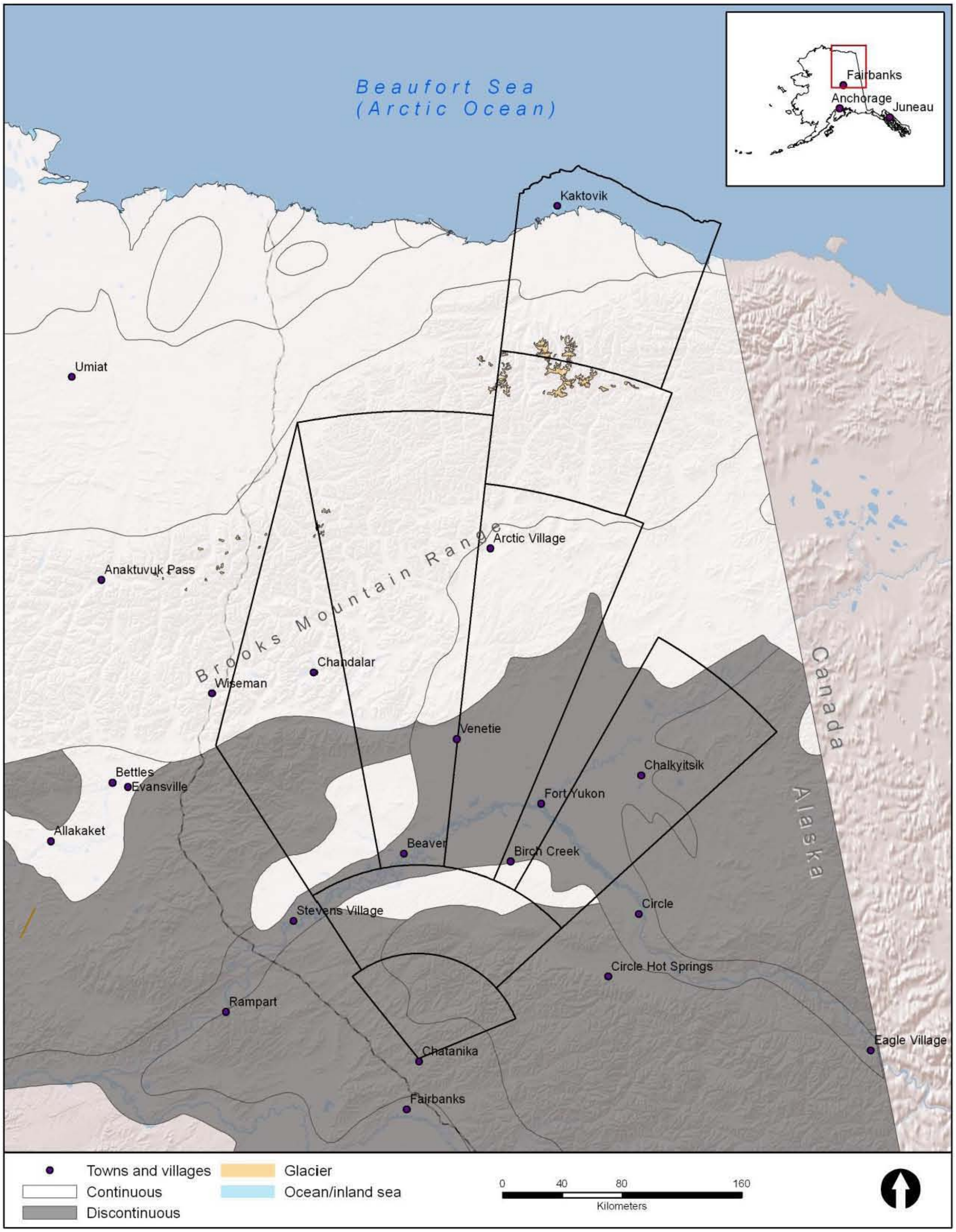
Table 3–10. Poker Flat Research Range Permafrost[a]

Ecoregion (ID Number)	Continuous Permafrost (hectares/percentage)[a]	Discontinuous Permafrost (hectares/percentage)	Total (hectares)
Arctic Coastal Plain (101)	160,000/100	0/0	160,000
Arctic Foothills (102)	460,000/100	0/0	460,000
Brooks Range (103)	4,100,000/100	0/0	4,100,000
Interior Forested Lowlands and Uplands (104)	480,000/32	990,000/68	1,500,000
Interior Highlands (105)	1,200,000/51	1,100,000/49	2,300,000
Yukon Flats (107)	500,000/21	1,900,000/79	2,400,000
Grand Total			**11,000,000**

a. Metrics denote the approximate area of permafrost in the Poker Flat Research Range portion of each ecoregion.
Note: To convert hectares to acres, multiply by 2.4710.
Source: Brown *et al.* 2001.

A major effect of permafrost soils is the presence of the frozen permafrost layer that causes water to saturate the active layer and perch on the surface of lowlands, creating wetlands. In some cases, frozen soil layers may contain large amounts of ground ice **(USDA 2004)**. In unconsolidated soils with poor drainage, ice masses range from small granules to ice wedges that can account for 50 to 80 percent of the permafrost **(French 2007; Ray 1950)**. Although the permafrost layer may impede or restrict water movement, it is not uncommon for the talik layer to contain unfrozen layers that facilitate groundwater movement through the soil, which often results in the formation of perennial springs **(French 2007)**.

Typically, permafrost thawing proceeds from the top downward and, eventually, from the bottom upward. Thawing discontinuous permafrost generally ranges from decades to millennia **(Bockheim and Hinkel 2007; Osterkamp and Jorgenson 2009)**. Cryoturbation (mixing of materials from various soil horizons due to freezing and thawing) is common to permafrost-affected soils and causes soil horizons to be broken and contorted **(USDA 2004)**.



Note: To convert kilometers to miles, multiply by 0.6214.
Source: SAIC 2011.

Figure 3–3. Poker Flat Research Range Permafrost

Climatic warming trends (see Section 3.1.2) resulting in the thawing of Arctic region permafrost could increase the depth of the active layer, increase groundwater discharge, soil drainage and drying, soil erosion, and landslides; release soil-sequestered carbon; and increase thermokarst terrain. Thermokarst is the thawing of permafrost with excessive ground ice, causing ground subsidence and irregular topography. Collect of water within pits or depressions leads to formation of small water bodies and growth of underlying taliks and further accelerates permafrost thawing **(Riordan 2005; USFWS 2011c)**. As soil temperatures increase, permafrost degradation is inevitable **(Bockheim and Hinkel 2007; Hinkel and Nelson 2003; Jorgenson *et al.* 2006; Osterkamp and Jorgenson 2009; von Hugues 2008)**. In addition, the disturbance of Gelisol organic active layers by wildfires – particularly in the Yukon Flats, Interior Highlands, and Interior Forested Lowlands and Uplands Ecoregions – may also affect permafrost environments **(Gallant *et al.* 1995)**. Because of frequent lightning strikes, wildfires are common to the subarctic boreal forest **(Riordan 2005)**.

Groundwater can occur above, below, and within permafrost **(Williams 1970)**. However, climate driven thawing of permafrost is altering the groundwater systems of the Arctic and subarctic regions. Studies by **Muskett and Romanovsky (2011)** found that the groundwater storage by bogs, depressions, and thaw lakes in the Arctic Coastal Plain Ecoregion (see Section 3.3.4.2) is increasing, whereas groundwater storage in the Yukon Flats Ecoregion (see Section 3.3.4.7) is decreasing. These changes are possibly linked to the development of taliks that are increasing the surface area of water bodies in the Arctic and reducing permafrost extent in the Yukon River basin. Talik layer water flows interact directly with the hydrology of surface water features. As an example, groundwater sources comprise approximately one-fourth of the water discharged by the Yukon River **(Walvoord and Striegl 2007)**.

3.4.2 Volcanoes

Of the approximately 140 volcanoes in Alaska that have been active over the last 2 million years, over 50 have been active since about 1700 **(Adleman 2011)**. Most volcanic activity has been located in the Aleutian Islands, Alaska Peninsula, and the mountains west of Cook Inlet **(Robar *et al.*)**. The U.S. Geological Survey, Alaska Volcano Observatory, monitors 27 active volcanoes on a daily basis. Since 1760, over 260 eruptions from 41 volcanoes have been reported **(Brantley *et al.* 2004)**. Mount Spur, the northernmost historically active volcano in Alaska **(Adleman 2011)**, is approximately 450 kilometers (280 miles) southwest of Fairbanks. No active volcanoes or volcanic fields are known to occur within PFRR.

3.4.3 Glaciers

The glaciations of the Pleistocene Epoch dramatically affected the landscape of Alaska through the construction of outwash terraces and moraines and erosion and sediment deposition processes **(Balascio *et al.* 2005; Briner and Kaufman 2008)**. The maximum extent of Pleistocene glaciations and current extent of glaciers cover the Philip Smith, Franklin, Sadlerochit, Shublik, Romanzof, and Davidson Mountains on the north and south sides of Brooks Range **(Balascio *et al.* 2005; Molnia 2008)**. There are approximately 41,000 hectares (101,000 acres) of glaciers within the Brooks Range Ecoregion. Most of the notable glaciers occur in higher-elevation cirques and valleys of the Franklin and Romanzof Mountains. Two prominent features include the Romanzof Mountains McCall and Okpilak Glaciers **(Molnia 2008)**. Since the early 1800s, McCall Glacier has retreated over 800 meters (2,600 feet) **(USFWS 2011c)**. Glacier melt water contributes considerably to the summer flow of Arctic rivers and streams **(Arendt 2006)**.

3.4.4 Soil Orders

The taxonomic classification used to describe soils within the ROI is soil order. **Table 3–11** lists the soil orders.

Table 3–11. Poker Flat Research Range Soil Orders

Soil Order	Description
Entisols	Entisols exhibit little or no soil-forming processes or development of soil horizons. Predominant textures include sand, sandy loam, sandy clay loam, and silty clay loam. In Alaska, these soils typically occur on river floodplains subjected to frequent sediment deposition, uplands adjacent to major rivers that receive windblown riverbed sediments, recently exposed glacial moraines, and very cold or steep areas prone to erosion.
Gelisols	Gelisols are defined as soils having permafrost within 100 centimeters of the soil surface or having gelic materials within 100 centimeters and permafrost within 200 centimeters of the soil surface if the top meter shows evidence of cryoturbation. Gelic materials include mineral or organic soil materials that show evidence of cryoturbation and/or ice segregation in the active layer and/or the upper part of the upper permafrost. Soils classified as Cryosols (perennial frozen or permafrost-affected soils) taxonomically key out at the Gelisol Order. Soil genesis is dominated by cryopedogenic processes, such as freeze-thaw cycles, cryoturbation, ice segregation, and frost cracking.
Inceptisols	Inceptisols are soils that have experienced relatively minor changes in parent materials, resulting in the leaching and accumulation of materials in subsurface layers or horizons. They form mainly under humid conditions in loamy and clayey parent materials. These soils range from poorly to excessively drained. Soil textures range from sandy loams to silty clays. Most soils in Alaska are Inceptisols.
Spodosols	Spodosols are poorly drained, naturally infertile soils in which materials such as organic matter, aluminum, and/or iron have leached through the soil profile and accumulated in a lower layer in the soil profile, called a spodic horizon. These soils form in relatively acidic soil materials. The soil texture class is mostly sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty. In Alaska, these soils are dominant in uplands, and, except for areas with very course materials and some tundra locations, typically occur in areas where the mean annual precipitation exceeds 38 centimeters.

Note: To convert centimeters to inches, multiply by 0.3937.
Source: Schickhoff *et al.* 2002; Osterkamp and Jorgenson 2009; Ping *et al.* 2004; Rieger *et al.* 1979; USDA 2010.

3.4.5 Ecoregions

This section describes the geologic and soil resources within the ROI based on the ecoregion descriptions provided in Section 3.2.

3.4.5.1 *Arctic Coastal Plain Ecoregion*

The area geology is defined by Quaternary deposits of alluvial, glaciofluvial, or aeolian unconsolidated sediments underlain with fluvial sands and silts and marine sediments near the coast **(Clough *et al.* 1987; Gallant *et al.* 1995)**. This ecoregion was never glaciated primarily because of the scarcity of precipitation **(Hall 1979; USFWS 2011c)**. The area is dominated by very poorly drained, organic Gelisol soils that developed under thick, low shrubby vegetation over fine silt loams and silty clay loams **(Gallant *et al.* 1995; Schickhoff *et al.* 2002)**. Typically, soils thaw to a depth of less than 46 centimeters (18 inches) in the summer **(Clough *et al.* 1987)**. These peat and loamy soils primarily occur in shallow depressions and drains and borders of the lakes formed from the thawing of ground ice **(Ping *et al.* 2004)**. Well to moderately drained gravelly soils have developed from stream channel deposits **(Gallant *et al.* 1995; Hall 1979)**.

Approximately 100 percent (160,000 hectares [404,000 acres]) of the PFRR portion of the Arctic Coastal Plan Ecoregion is underlain with continuous permafrost (see Table 3–10 and Figure 3–3) that generally ranges in thickness from 200 to 400 meters (650 to 1,300 feet). Continuous permafrost may extend to depths of greater than 400 meters (1,300 feet) in some areas **(Riordan 2005)**. Active layers generally range from 0.3 to 1.2 meters (1 to 4 feet) thick **(USFWS 2011c)**. Minor variations in tundra elevation due to freezing and thawing of the active layer are common **(ADNR 2006)**. Surface features include ice wedge polygons, thaw lakes, peat ridges, frost boils, icings, and pingos (mounds of earth-covered ice 6 to 70 meters [20 to 230 feet] high) **(Gallant *et al.* 1995)**. The continuous permafrost has a strong influence on the hydrologic cycles of the Arctic Coastal Plain Ecoregion **(French 2007)**. The permafrost functions as a relatively impermeable layer, creating shallow, wet tundra during summer that has severely limited water storage capacity. Water that accumulates above the permafrost is removed by evapotranspiration and surface runoff that generally drains toward the Beaufort Sea **(Schickhoff *et al.* 2002)**.

3.4.5.2 *Arctic Foothills Ecoregion*

This predominantly treeless region of moderately steep to steep hills and broad, sloping valleys and tundra are underlain with continuous permafrost **(USFWS 2011c)**. Approximately 100 percent (460,000 hectares [1,200,000 acres]) of the Arctic Foothills Ecoregion within the ROI is underlain with continuous permafrost (see Table 3–10 and Figure 3–3). The active layer is generally less than 1 meter (3 feet) thick **(Gallant *et al.* 1995; Ping *et al.* 2004)**. Slopes typically range from 0 to 10 percent, with some areas being much steeper. Elevations range from sea level to 900 meters (3,000 feet) **(Gallant *et al.* 1995)**.

The northern portion of the Arctic Foothills Ecoregion comprises Quaternary deposits of unconsolidated glacial alluvial and aeolian materials over Lower Cretaceous continental deposits. The higher southern portion of the foothills consists of undifferentiated alluvial and colluvial deposits overlying Jurassic and early Cretaceous formations. Parts of the southern portion of the Arctic Foothills Ecoregion near the Brooks Range Ecoregion were glaciated during the Pleistocene epoch **(Ping *et al.* 2004)**. Ice- and drainage-related surface features include patterned ground, gelifluction lobes, frost boils, ice-wedges, and pingos **(Schickhoff *et al.* 2002)**. Arctic Foothills Ecoregion soils are predominantly Gelisols. In the valleys and on broad slopes, soil parent materials are primarily loamy colluviums (slope deposits due to gravity), whereas on hills and ridges, the parent materials are primarily gravelly colluviums and weathered sedimentary rocks. Soil texture is primarily silt loam or silty clay loam in the northern portion and sandy loam in the southern portion of the foothills. Most soils on mild slopes and broad valleys are poorly drained **(Ping *et al.* 2004)**. Peaty soils often form in the valley floors and sandy soils occur in dunes along streams **(Clough *et al.* 1987)**. Surface tundra active layer depths generally range from a few centimeters to a meter, with an average of approximately 25 to 40 centimeters (10 to 16 inches) **(Greenwald *et at.* 2008)**. Thawed talik layers tend to develop in tundra and beneath streams during summer **(Greenwald *et at.* 2008)**.

3.4.5.3 *Brooks Range Ecoregion*

Approximately 100 percent (4.1 million hectares [10 million acres]) of the Brooks Range Ecoregion is underlain with continuous permafrost (see Table 3–10 and Figure 3–3). This ecoregion comprises a wide belt of rugged, linear mountain ranges carved primarily by numerous glacial advances and differential erosion from uplifted Paleozoic and Mesozoic sedimentary rock formations. Current glaciers only persist at high elevations (see Section 3.4.3). The region is drained by north- and south-flowing rivers. The southern section of the ecosystem is characterized by buttes, knobs, mesas, ridges, and undulating tundra, and the northern section has broad, rounded ridges and mesa-like uplands **(Schickhoff *et al.* 2002)**. Ice- and drainage-related features include moraine and grave outwashes, hillslope gelifucation lobes, ice push ridges, frost action scars, and soil erosion. Because of the permafrost, most soils in the ecoregion are poorly to very poorly drained and shallow to moderately deep Gelisols. Better-drained hillslopes generally formed from colluvium and valley floors, from gravelly glacial till. Gently sloping areas often have shallow, gravelly and stony soils **(Gallant *et al.* 1995; USFWS 2011c)**. Poorly drained loamy soils overlain with peat are primarily found in low areas near rivers **(Clough *et al.* 1987)**.

3.4.5.4 *Interior Forested Lowlands and Uplands Ecoregion*

The Interior Forested Lowlands and Uplands Ecoregion geology includes Mesozoic and Paleozoic sedimentary formations and areas of extensive volcanic deposits with minimal exposure of bedrock **(Brabets *et al.* 2000)**. The terrain has been strongly influenced by the mantling of undifferentiated alluvium (stream sediments) lowland deposits and colluvial upland deposits and thermokarsting of soils with high quantities of ground ice. Primary soils within the ecoregion include Entisols, Gelisols, and Inceptisols. The majority of lowland soils formed within broad river floodplains from silty alluvium and loess materials, whereas uplands soils were formed primarily from colluvial and loess deposits and bedrock weathering. Organic soils frequently occur on very acidic, nearly level peatland plateaus **(Gallant *et al.* 1995; Ping *et al.* 2004)**. Some areas experience extensive thermokarsting where permafrost soils contain large amounts of ground ice. Well-drained permafrost-free soils may occur within river floodplains **(Ping *et al.* 2006)**.

3.4.5.5 *Interior Highlands Ecoregion*

The northern section of the Interior Highlands Ecoregion within the ROI is underlain with approximately 51 percent (1.2 million hectares [2.9 million acres]) continuous permafrost and the remaining area, 49 percent (1.1 million hectares [2.7 million acres]) discontinuous permafrost (see Table 3–10 and Figure 3–3).

Geologic formations include metamorphic, volcanic, intrusive, and sedimentary rocks. Dominant soils are shallow, poorly drained Entisols, Gelisols, Inceptisols, and Spodosols that formed primarily from gravels weathered from local bedrock. Valley floor parent materials are alluvium and colluviums deposits **(Gallant *et al.* 1995)**. Stony and loamy tundra soils occur at higher elevations. Thermokarst is widespread in this ecoregion since permafrost soils are frequently ice-rich **(Ping *et al.* 2004)**. Compared to Arctic streams, water courses in the Interior Highlands Ecoregion tend to exhibit peak flows following the spring snowmelt, but moderate flows during the summer **(USFWS 2011c)**. Major Interior Highlands Ecoregion rivers within the ROI include the Chandalar, Christian, East Fork, Koness, Middle Fork, North Fork, Sheenjek, and Wind Rivers **(Childers *et al.* 1977; Daum and Troyer 1992)**.

3.4.5.6 *Yukon Flats Ecoregion*

The Yukon Flats Ecoregion contains Quaternary and earlier unconsolidated eolian (windblown sand or rock deposits), glaciofluvial, and fluvial sediments that have underlying bedrock. Dominant soils include Gelisols and Inceptisols that formed within the alluvium and loess materials of river floodplains that are frequently subject to flooding. Except for better-drained silt and sandy soils along river and stream natural levees, areas outside the basin floodplain are often poorly drained peatlands with shallow permafrost **(Gallant *et al.* 1995; USFWS 2008b)**. Terraces along the margins of the lowlands are covered with loess silt materials underlain with gravel **(Nakanishi and Dorava 1994)**. Except for larger rivers and lakes and recently abandoned meander belts **(Nakanishi and Dorava 1994)**, the ecoregion is underlain with continuous and discontinuous permafrost. The areas of the ROI within this ecoregion are underlain with approximately 21 percent (490,000 hectares [1.2 million acres]) continuous permafrost and 79 percent (1.9 million hectares [4.7 million acres]) discontinuous permafrost (see Table 3–10 and Figure 3–3).

3.5 NOISE

Noise is unwanted sound that interferes or interacts negatively with the human or natural environment. Noise may disrupt normal activities or diminish the quality of the environment. The ROI for the noise analysis includes the PFRR launch site and launch corridor.

Sound is quantified in units called *decibels (dB)*. The dB scale used to describe sound is a logarithmic scale that provides a convenient system for considering the large differences in audible sound intensities. On this scale, a 10 dB increase represents a perceived doubling of loudness to someone with normal hearing. Therefore, a 70 dB sound level will sound twice as loud as a 60 dB sound level. However, a doubling of sound energy only results in a 3 dB increase in sound level. For example, adding together two identical noise sources of 60 dB results in a total noise level of 63 dB (60 dB + 60 dB = 63 dB). Under ideal listening conditions, people generally cannot detect differences of 1 dB, while differences of 2 or 3 dB can usually be detected by people with normal hearing.

An adjustment, or weighting, of the high and low-pitched sounds is made to approximate the way that an average person hears sounds. The adjusted sounds are called “A-weighted levels” (dBA). The A-weighted decibel scale begins at zero. This represents the faintest sound that can be heard by humans with very good hearing. The loudness of sounds (that is, how loud they seem to humans) varies from person to person, so there is no precise definition of loudness.

Sound levels decrease as the distance increases from the sound source. This loss of energy, known as attenuation, is affected by geometrical spreading, atmospheric absorption, and the interaction of the sound waves with the ground surface. *Geometrical spreading* refers to the spreading of sound energy as a result of the expansion of the wavefronts. For a *point source*, such as a chainsaw, sound levels decrease due to spreading by approximately 6 dB for every doubling of distance from the source. An overflying aircraft is considered a *line source*, which typically results in a sound level reduction of 3 dB per doubling of distance.

Atmospheric absorption is the loss of sound energy as it travels through the air, which varies strongly with the frequency of the sound wave and the temperature, humidity, and, to a minor extent, the atmospheric pressure. This loss is greatest at high frequencies and in hot, dry air. Under normal conditions the atmosphere is cooler at higher altitudes, which results in sound waves being "bent" upwards, resulting in the formation of a shadow zone, which is a region in which sound does not penetrate. Under conditions of a temperature inversion (temperature increasing with increasing height), the sound waves will be refracted downwards, and therefore may be heard over larger distances. This frequently occurs in winter and at sundown. Variations in the atmosphere will also cause scattering, during which some of the sound energy is re-directed into many different directions. Scattering is caused by air turbulence, rough surfaces, and obstacles such as trees. Temperature and wind gradients can result in measured sound levels being very different to those predicted from geometrical spreading and atmospheric absorption alone. These differences may be as great as 20 dB **(Ingård 1953)**. These effects are particularly important where sound is propagating over distances greater than a few hundred meters.

The amount of *ground attenuation* depends on the nature of the ground, the frequency of the sound, the distance over the ground, and the source and receiver heights. Smooth, hard surfaces will produce little absorption, whereas thick grass may result in sound levels being reduced by up to about 10 dB per 100 meters at 2,000 hertz (Hz). Ground attenuation is typically limited to about 20 dB as the distance between the source and receiver increases, due to the effects of turbulence and scattering **(Sutherland and Daigle 1997)**. The presence of vegetation, particularly trees, provides some attenuation; however, trees of several hundred meters thick are required before substantial attenuation occurs **(Aylor 1971)**. High frequencies are generally attenuated more than low frequencies.

The propagation of sound can be affected greatly by terrain and the elevation of the receiver relative to the sound source. Noise travels in a straight line-of-sight path between the source and the receiver. The presence of an area of high terrain reduces the sound energy arriving at the receiver. Breaking the line of sight between the receiver and the sound source results in a sound level reduction of approximately 5 dB. If the source is depressed (*e.g.,* in a valley) or the receiver is elevated (*e.g.,* on a mountainside), sound generally will travel directly to the receiver. In some situations, sound levels may be reduced because the terrain crests between the source and the receiver, resulting in a partial sound barrier near the receiver. Level ground is the simplest case.

The importance of these various phenomena depends upon the situation under consideration. For example, for a chainsaw on the ground and a receiver close by, only geometrical spreading and large obstacles need to be considered. However, if the receiver is a large distance from the chainsaw, then ground effects and atmospheric effects must be considered. If an aircraft is flying overhead, then only geometric spreading and atmospheric effects need to be considered.

Areas near the PFRR launch site are used primarily for recreation, mineral recovery, and forestry. The closest noise-sensitive receptor, the Chatanika Lodge, is located about 1.6 kilometers (1 mile) south-southwest of the PFRR launch site adjacent to Steese Highway (Alaska Route 6). The primary source of noise in this area is traffic noise along Steese Highway. Recreation users and visitors at the Chatanika Lodge may be sensitive to noise produced by activities at PFRR. Areas near PFRR that are not close to the highway are naturally quiet. There are no ambient sound level survey data available for the area near the PFRR launch site.

Sources of noise from daily activities at the PFRR launch site include ventilation systems, delivery vehicles, and employee vehicles. Occasional noise sources include generators, rocket launches, and aircraft involved in recovery operations. Noise from rocket launches and recovery aircraft (*i.e.,* fixed wing propeller planes and helicopters) is discussed in Chapter 4. Based on the number of daily commuter trips to the PFRR launch site and the traffic volume on Steese Highway **(ADOT&PF 2010)**, the contribution of employee vehicles and delivery vehicles attributable to activities at the PFRR launch site to noise along Steese Highway is minor.

Areas within the PFRR launch corridor in which rocket debris and science payloads would land and search and recovery operations would be conducted include parts of Arctic NWR, Yukon Flats NWR, White Mountains NRA, Steese NCA, and various villages and other inhabited areas. Users of wildlife refuges and recreation and conservation areas may have the expectation of solitude **(USFWS 2011c)**. These refuges and recreation areas are naturally quiet except for natural sounds from wind and wildlife. Occasional aircraft overflights and snow machines in recreation areas interrupt the natural quiet in these areas. There are no ambient sound level survey data readily available for these refuges and recreation and conservation areas.

The inhabited areas, although generally quiet, are subject to vehicle noise, higher levels of aircraft activity, and other sounds of human activity. There are no ambient sound level survey data readily available for these inhabited areas.

The ambient sound in the Arctic Ocean under the ice results from the effects of wind, currents, ambient air temperature, sounds of marine mammals, and ice cracking. Ice cracking results from the combination of stresses on the ice, including wind, currents, and thermal stresses. Ice cracking creates a sharp broadband sound. The frequency characteristics of ice cracking vary with the age of the ice (first year or multi-year). The combination of many such events in the floating ice pack is the predominant noise source under the ice in the Arctic Ocean **(Xie and Farmer 1991)**. Mid-frequency sound from ice (centered on 600 Hz) has been best correlated with temperature, and lower-frequency sound (centered at 15 Hz) has been best correlated with wind, which moves ice granules on the surface of the ice pack **(Makris and Dyer 1986)**. The wind-generated wave interaction between open ocean and ice is a major source of sound near the ice/water boundary. Low-frequency sound from this interaction carries greater distances than the higher-frequency sound **(Diachok 1980)**.

Milne and Ganton (1964) report ice pack noise from ice cracking which when converted to sound pressure levels, ranges from about 90 dB (referenced to 1 micro Pascal) in the lower frequencies (1 Hz) to about 45 dB (referenced to 1 micro Pascal) in the higher frequencies (100–10,000 Hz). **Ganton and Milne (1965)** report noise under the ice pack from wind-induced sounds, which ranges from about 50–55 dB (referenced to 1 micro Pascal) in the higher frequencies (100–10,000 Hz) with a wind speed of 9.8 meters per second (22 miles per hour). Lower-frequency (10–100 Hz) sound levels of about 50 dB (referenced to 1 micro Pascal) under these conditions were the result of residual impulsive noise (from ice cracking and distant noise).

Sound levels (presented in decibels referenced to 1 micro Pascal at 1 meter) from various noise sources in the ocean include lightning strike on water surface, 260 dB; bowhead whale, 128–189 dB; and gray whale, 142–185 dB. Sound is attenuated in the ocean at a rate of about 6 dB for each doubling of distance **(USN 2011)**. Actual attenuation of sound is dependent on frequency; the presence of sound channels, which may result in transmission of sounds of certain frequencies over greater distances; and reflection of sound off the ice canopy **(Diachok 1980)**.

The State of Alaska and Fairbanks North Star Borough have no regulations that specify acceptable sound levels **(Fairbanks North Star Borough Code 2011)**.

3.6 VISUAL RESOURCES

Visual resources are the natural and manmade features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. All four elements are present in every landscape; however, they exert varying degrees of influence. The stronger the influence exerted by these elements in a landscape, the more interesting the landscape. The ROI for visual resources includes areas within the PFRR launch site and the PFRR launch corridor.

To provide a basis for the impact analysis in Chapter 4, visual resource assessments were made for the federally managed lands within the ROI based on a description of the viewshed and U.S. Bureau of Land Management (BLM's) visual resource management (VRM) classification **(USDOI 1986a)**. Classifications of visual contrast settings are provided in **Table 3–12**. Classifications were derived from an inventory of scenic qualities, sensitivity levels, and distance zones for particular areas.

Table 3–12. U.S. Bureau of Land Management Visual Resources Classifications

Classification	Visual Settings
Class I	Very limited management activity; natural ecological change.
Class II	Management activities may be seen, but should not attract the attention of the casual observer, such as solitary small buildings or dirt roads.
Class III	Management activities may attract attention, but should not dominate the view of the casual observer; the natural landscape still dominates buildings, utility lines, and secondary roads.
Class IV	Management activities may dominate the view and major focus of viewer attention, such as clusters of two-story buildings, large industrial or office complexes, primary roads, and limited clearcutting for utility lines or ground disturbances.

Source: USDOI 1986a.

3.6.1 Poker Flat Research Range Launch Site

The PFRR launch site includes the Lower, Middle, and Upper Ranges. The Lower Range includes range offices, rocket launch facilities, blockhouse, pad support, and a rocket storage building. The area is relatively flat, with an average elevation of 200 meters (660 feet) above mean sea level. The Middle Range includes the area with the telemetry buildings and optical observatory. It is approximately 200 meters (700 feet) higher in elevation than the Lower Range. The Upper Range includes the area on the ridge top above the Lower and Middle Ranges. The Upper Range's elevation extends to 500 meters (1,600 feet) above mean sea level. Facilities in the Upper Range include a self-contained trailer, which houses electrical gear, and a short radar tower **(NASA 2000a)** (see Chapter 2). The PFFR launch site is consistent with BLM VRM Class III or IV. Class III indicates areas in which there have been moderate changes in the landscape that could attract attention, but do not dominate the view of the casual observer. Class IV indicates areas in which major modifications to the character of the landscape have occurred. These changes may dominate features of the view and become the major focus of the viewer's attention **(USDOI 1986a)**.

3.6.2 Poker Flat Research Range Launch Corridor

The PFRR launch corridor encompasses a vast portion of interior and northern Alaska. Downrange from the launch site are White Mountains NRA; Steese NCA; Arctic NWR, including Mollie Beattie Wilderness Area; and Yukon Flats NWR (see Figure 3–1). Also located within the PFRR launch corridor are landmasses owned by Alaska Native organizations, including Doyon, Limited, and the Native Village of Venetie Tribal Government.

3.6.2.1 *White Mountains National Recreation Area*

White Mountains NRA is administered by BLM. ANILCA **(P.L. 96-487)** directs that White Mountains NRA be administered to provide for public outdoor recreational use; for the conservation of scenic, historic, cultural, and wildlife values; and for other uses if they are compatible or do not significantly impair the previously mentioned values **(USDOI 1986b)**. BLM manages White Mountains NRA to enhance and protect the important resource values that make White Mountains NRA unique. These values include, among others, the outstanding scenic quality of the viewshed and unique landforms and geologic formations such as the White Mountains, Windy Gap Arch, Serpentine Slide, and Victoria Mountain **(USDOI 1986b)**. BLM manages the Beaver Creek viewshed as a VRM Class I area and the White Mountain Trail as VRM Class II area. The objective of this class is to retain the existing character of the landscape and maintain a low level of change to the landscape. Management activities in VRM Class II areas may be seen but should not attract the attention of the casual observer **(USDOI 1986b)**. Other areas within White Mountains NRA, such as portions of the Semi-Primitive Management Unit, are managed as VRM Class III areas **(USDOI 1986b)**.

3.6.2.2 *Steese National Conservation Area*

Steese NCA is administered by BLM and includes Birch Creek, a designated Wild River, crucial caribou calving grounds and home range, and Dall sheep habitat. Various land uses are allowed in Steese NCA; however, it is managed to protect its scenic, scientific, cultural, and other resources **(USDOI 2011a)**. BLM manages the Birch Creek National Wild River Corridor within Steese NCA as a VRM Class I area. The objective of this VRM class is to preserve the existing character of the landscape so that it appears unaltered by man. The level of change to the landscape should be extremely low because only very limited management activities should occur. BLM manages the viewshed of Birch Creek as a VRM Class II area. BLM manages the Semi-Primitive Motorized Restricted Management Unit within Steese NCA as a VRM Class III area, with areas of the unit determined to be within the critical viewshed for Birch Creek managed to VRM Class II objectives **(USDOI 1986c)**.

3.6.2.3 *Arctic National Wildlife Refuge*

Administered by USFWS, Arctic NWR was established for the purpose of preserving its unique wildlife, wilderness, and recreational values **(USFWS 2011c)**. The Neruokpuk Lakes Public Use Natural Area, within Arctic NWR, is the only public use natural area in Arctic NWR. It is located in Brooks Range, entirely in the designated Wilderness area. It was chosen as a public use natural area because of its relative ease of access, scenic beauty, and abundant wildlife. The Ivishak, Sheenjek, and Wind Rivers are located within the boundaries of Arctic NWR and are designated as wild rivers under the Wild and Scenic Rivers Act. USFWS manages these water bodies in natural, free-flowing, and undisturbed conditions, where the evidence of human activities is minimized. Mollie Beattie Wilderness Area is located within Arctic NWR and contains more than 40 percent of Arctic NWR. The Wilderness area’s character includes natural and scenic conditions. Because of distinctive scenic and scientific features within Arctic NWR, several rivers, valleys, canyons, lakes, and a rock mesa have been recommended as National Natural Landmarks **(USFWS 2011e)**. Arctic NWR is consistent with the BLM and VRM Class I and Class II.

3.6.2.4 *Yukon National Wildlife Refuge*

The Yukon River flows through the center of Yukon Flats NWR and drains a broad floodplain patterned with braided tributaries and pocked with lakes and ponds. The basin floor gently slopes up to the White Mountains to the south of Yukon Flats NWR and Brooks Range to the north. Beaver Creek is a clear, sinuous river that flows out of the White Mountains and empties into the Yukon River. The White Mountains are scenic white limestone mountains; rugged and isolated, they receive only limited use and remain virtually undisturbed by human development. The environment consists mainly of geographic landmarks, Alaska Native villages, fishing and hunting grounds, lakes, wetlands, creeks, and riverway landscapes. The topography of the region is characteristic of flat to undulating lowlands, surrounding uplands, and encompassing highlands and mountains. The land cover is a mixture of spruce forests, white birch, quaking aspen, balsam poplar, shrubs, and bogs, including tussock tundra. Because of the flat to gently sloping topography of the majority of the Yukon Flats NWR landscape, and successional forests in many areas, views are principally composed of foreground to middle-ground scenery elements that are consistent with recreation, hunting, and fishing. The foreground and middle ground are areas that can be seen from each travel route for a distance of up to 8 kilometers (5 miles), where management activities might be viewed in detail.

The extensive network of rivers and historic trails affords residents and visitors with viewing opportunities throughout Yukon Flats NWR. Views along rivers and trails typically range from foreground (up to 1 kilometer [0.6 miles] from the viewer) to middle ground (up to 6 kilometers [4 miles] from the foreground) and background (area beyond the foreground-middle ground zone that can be seen from each travel route to the horizon, or approximately 24 kilometers [15 miles]); it does not include areas in the background that are so far distant that the only thing discernible is the form or outline). There are several "special designation areas" in the Yukon Flats region that are afforded special status to preserve certain outstanding values. Special designations in the region include Beaver Creek Wild River (26 kilometers [16 miles] of which are within Yukon Flats NWR) and Birch Creek Wild River (no section of Birch Creek within Yukon Flats NWR holds special designation) and possibly the Lower Sheenjek River (160 kilometers [99 miles] of which are within Yukon Flats NWR), if designated in the future as a Wild River by Congress. These locations fit recognized standards for designation as areas of high aesthetic value. In addition, a portion of Yukon Flats NWR bordered by the White and Crazy Mountains has been recommended for Wilderness designation **(USFWS 2010a)**. Yukon Flats NWR is consistent with the BLM VRM Class I and Class II.

3.7 ECOLOGICAL RESOURCES

Ecological resources include plant and animal species, along with the habitats in which they occur. This section discusses vegetation, wildlife, and special status species. Water resources, including wetlands, are discussed separately in Section 3.3. The ROI for ecological resources includes the PFRR launch site, as well as the entire launch corridor. Wildlife descriptions focus primarily on large mammals (both terrestrial and marine), birds (migratory and resident), and fish. Vegetation found within the ROI is discussed within the ecoregion descriptions. For a more in depth description of vegetation found within the ROI and the vicinity, refer to **Viereck *et al.* (1992)**. Special status species refer to all plants or animals with a designation of endangered, threatened, or candidate status from USFWS, NOAA Fisheries Service, or the State of Alaska. Additionally, sensitive species identified by BLM are discussed.

3.7.1 Vegetation

Due to the extent and complexity of ecological resources occurring within the ROI, a description of ecoregion divisions has been employed to simplify the discussion. Ecoregions can best be described as geographical units identified by their environmental conditions, such as climate, soil type, and species composition. Ecoregion descriptions in this section follow the designations and descriptions set forth in **Gallant *et al.* (1995)**, as discussed in Section 3.2 and shown in Figure 3–2.

The Arctic Coastal Plain Ecoregion is the northernmost ecoregion. It is a true Arctic climate, characterized by very low temperatures and precipitation. Many thaw lakes are present with thick permafrost below the surface. The area is poorly drained and treeless, with strong persistent winds. The Arctic Coastal Plain Ecoregion is dominated by wet graminoid herbaceous communities with a low chance of wildfire **(Gallant *et al.* 1995)**.

The Arctic Foothills Ecoregion also has an Arctic climate with low temperatures and precipitation. This area has better drainage than the coastal plain, with rolling hills and plateaus. It is still mostly treeless with thick permafrost. Mesic graminoid herbaceous and dwarf scrub communities dominate the vegetation. Occurrence of wildfires in the Arctic Foothills Ecoregion is very low. Fire sizes have historically ranged from less than 1 hectare (2.5 acres) to 1,600 hectares (4,000 acres), with an average size of 190 hectares (470 acres) **(Gallant *et al.* 1995)**.

Elevation in the steep, rugged Brooks Range Ecoregion varies from 800 meters (2,600 feet) to 2,400 meters (7,900 feet). Some small glaciers still exist in its highest regions. There is sparse dwarf scrub vegetation in this Arctic climate. There is a moderate amount of precipitation here, with more falling on the south-facing slopes near the summits. Occurrence of wildfires in the Brooks Range Ecoregion is common. Fire sizes have historically ranged less than 1 hectare (2.5 acres) to 109,000 hectares (270,000 acres), with an average size of 1,800 hectares (4,400 acres) **(Gallant *et al.* 1995)**.

Interior Forested Lowlands and Uplands Ecoregion have a continental climate with short, warm summers and long, cold winters. They are forest dominated with thaw and oxbow lakes, rivers, scrub communities, bogs, and swamps. Needleleaf forests are dominated by white spruce *(Picea glauca)* or black spruce *(Picea mariana)*; broadleaf forests are dominated by balsam poplar *(Populus balsamifera)*, quaking aspen *(Populus tremuloides)*, or both; and mixed forests are dominated by combinations of spruce, paper birch *(Betula papyrifera)*, and quaking aspen **(Gallant *et al.* 1995)**. Wildfires are common in this region. Other features include hills of moderate elevation and discontinuous permafrost. Precipitation ranges from 25 to 55 centimeters (9.8 to 22 inches) annually. Winter temperatures average from –35 °C to –22 °C (–31 °F to –7.6 °F) and from 11 °C to 22 °C (52 °F to 72 °F) in the summer. The PFRR launch corridor slightly intersects the westernmost edge of this ecoregion. Wildfires occur regularly in the interior forested lowlands and uplands region. Fire sizes have historically ranged from 1 hectare (2.5 acres) to 260,000 hectares (640,000 acres), with an average size of 1,600 hectares (4,000 acres). Low annual precipitation, relatively high summer temperatures, low humidity, and frequent lightning strikes make the ecoregion especially prone to wildfires. The fire season lasts from June to August **(Gallant *et al.* 1995)**.

The Interior Highlands Ecoregion is slightly mountainous, ranging from 500 to 1,500 meters (1,600 to 4,900 feet) in elevation. The ground is barren or has dwarf scrub vegetation, dominated by willows or ericaceous species, or open spruce stands dominated by white spruce or both white and black spruce **(Gallant *et al.* 1995)**. In poorly drained areas, graminoid herbaceous vegetation, dominated by sedges, persists. The area has a continental climate and permafrost in northern areas. Occurrence of fire in the interior highlands is very common due to the relatively warm summer temperatures and high number of lightning strikes. Fire sizes have historically ranged from less than 1 hectare (2.5 acres) to over 82,000 hectares (203,000 acres), with an average size of 640 hectares (1,600 acres). Similar to the Interior Forested Lowlands and Uplands Ecoregion, the wildfire season lasts from June until August **(Gallant *et al.* 1995)**.

The flat, marshy basin called the Yukon Flats Ecoregion supports needleleaf, broadleaf, and mixed forests (dominant species described above under the Interior Forested Lowlands and Uplands Ecoregions) as well as tall scrub communities and wet graminoid herbaceous communities. The tall scrub communities are dominated by a variety of willows (*Salix* spp.) and alders (*Alnus* spp.) or a mix of willows and alders. The variation exists in the climate type. Temperatures are more extreme here: summers are warmer and winters are colder. There is also less precipitation, averaging 17 centimeters (6.7 inches) per year. Occurrence of wildfires in the

Yukon Flats Ecoregion is common. Fire sizes have historically ranged from less than 1 hectare (2.5 acres) to over 32,000 hectares (79,000 acres), with an average size of 690 hectares (1,700 acres) **(Gallant *et al.* 1995)**.

Seasonal Considerations

Because of the length and north-south orientation of PFRR, the launch corridor extends over areas having considerable variation in climates, terrain, and vegetation. All areas under the corridor have an extended season during which the ground and water bodies are frozen and there is little plant growth. During this season, overland access, with minimum damage to vegetation, soils, or aquatic, is facilitated by the frozen ground and water surfaces, which will support a variety of vehicles adapted for travel on ice and snow. During the summer months, the surfaces thaw and plant growth is facilitated by the long day lengths, warmer temperatures, and availability of free water. The thawed soil and water surfaces make overland vehicular access very difficult in lowlands, which cause vehicles to bog down and can have substantial impacts on vegetation and soil. Because soils are generally underlain by permafrost, the thawed water on the surface is prevented from percolating downward, thereby creating swampy habitat. During the summer, rivers become important travel corridors for vessels and aerial access is possible by helicopter or float plane. Generally the more northerly areas have shorter warm seasons and shallower permafrost. The possibility of wildfire occurrence is very low, except during the summer months.

3.7.2 Wildlife

Although all wildlife within the ROI is ecologically important, this section focuses primarily on large mammals (terrestrial and marine), birds (migratory and resident), and fish. A more detailed description of ecological resources found in and around PFRR can be found in the *Proposed Land Exchange Yukon Flats National Wildlife Refuge Final Environmental Impact Statement* **(USFWS 2010a)**, as well as the *Arctic National Wildlife Refuge Draft Revised Comprehensive Conservation Plan, Draft Environmental Impact Statement, Wilderness Review, Wild and Scenic River Review* **(USFWS 2011c)**.

3.7.2.1 *Terrestrial Mammals*

The following provides a discussion of terrestrial mammals found within the ROI and adjacent areas. It focuses on big game and subsistence species.

Caribou

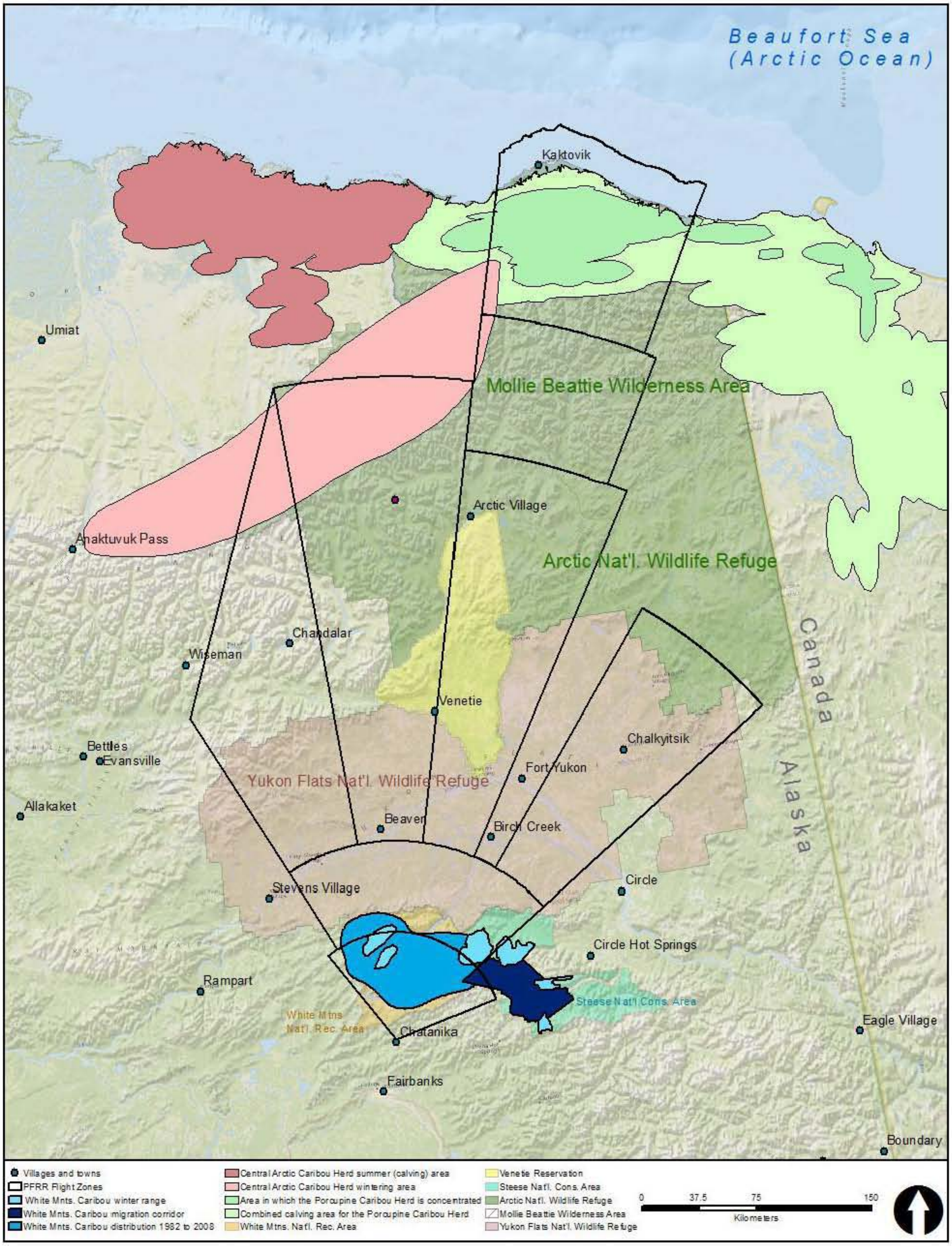
The PFRR launch corridor intersects the range of two of the four major North Slope barren-ground caribou *(Rangifer tarandus)* herds: the Porcupine Caribou Herd (PCH), which contained an estimated 169,000 animals in 2010 (**PCMB 2012**), and the westernmost portion of the range of the Central Arctic Herd (CAH), which contained an estimated 67,000 animals in 2008 (**AKRDC 2009**).Caribou are nomadic grazing animals and an important subsistence food for the Inupiat Natives of the North Slope of Alaska and the Gwich'in Natives of Canada. A herd uses a calving area that is separate from the calving areas of other herds, but different herds may mix together on winter ranges **(ADF&G 2008a)**. Caribou calves are born during the months of mid-to late-May in interior Alaska and in early June in northern and southwestern Alaska **(ADF&G 2008a)**. At times, caribou move to elevated areas and river deltas from July to August, seeking windy areas as relief from biting insects. In general, caribou herds, including PCH, are dispersed over a wider portion of their range during winter. A portion of PCH overwinters in northern Yukon Territory, Canada. Another portion of the herd winters in Alaska south of Brooks Range. Wolves *(Canis lupus)* are a major predator of caribou in wintertime **(USFWS 2008c)**. In addition to the PCH and CAH, the White Mountains caribou herd (WHM), estimated to be approximately 800 individuals, occupy the ROI year-round, primarily in the White Mountains NRA and the North Unit of the Steese NCA **(USDOI 2012a)**. **Figure 3–4** depicts the breeding (calving) and wintering (non-breeding) ranges for both the PCH and CAH, as well as the calving and post-calving range of the WMH.

Muskoxen

Muskoxen *(Ovibos moschatus)* are the only large mammals that overwinter on the Arctic Coastal Plain Ecoregion **(USFWS 2008d)**. Muskoxen were extirpated from northern Alaska in the early 20th century but were re-introduced to Arctic NWR in 1969. They have since expanded their range to the east and west of the Arctic NWR boundaries. Thick, hairy wool and other winter adaptations allow them to withstand the extreme cold of the Arctic winter. Adult females, young animals, and some males live in social groups year-round. Other males are solitary in summer and live together in winter **(USFWS 2008d)**. **Figure 3–5** shows the range of muskoxen, moose, and Dall sheep within the ROI.

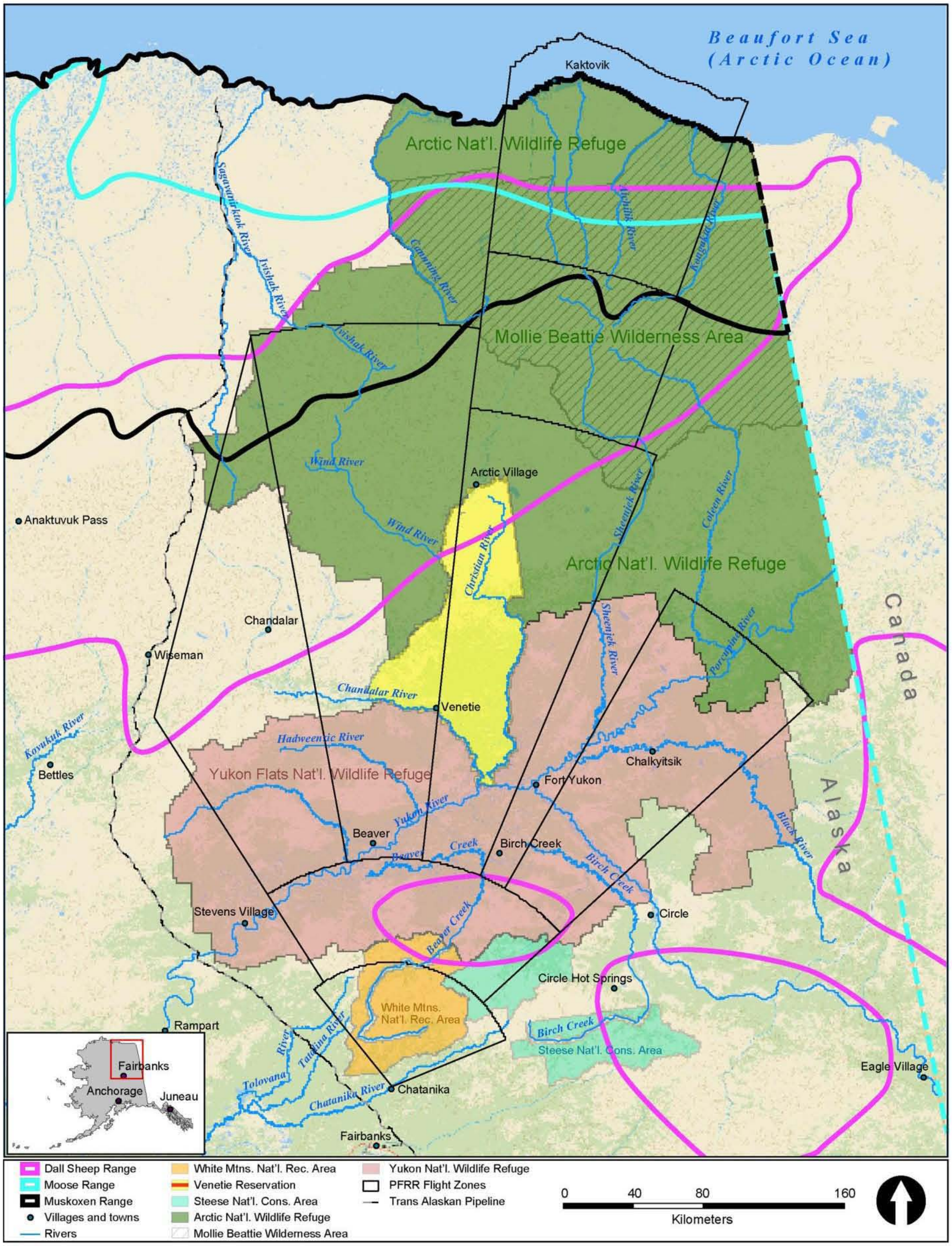
Moose

Moose *(Alces alces)*, the largest member of the deer family, is typically associated with interior Alaska, where they are prevalent. However, they are also present seasonally in the valleys of Brooks Range (including portions of Arctic NWR), where they overwinter **(Mauer 1998)**. The North Slope is the northernmost edge of distribution for this species **(USFWS 2008e)**. During fall and winter, moose consume large quantities of willow, birch, and aspen twigs **(ADF&G 2008b)**. Spring is the time of grazing and browsing **(ADF&G 2008b)**. Moose eat a variety of foods, particularly sedges, equisetum (horsetail), pond weeds, and grasses **(ADF&G 2008b)**. During summer, moose feed on vegetation in shallow ponds, forbs, and the leaves of birch, willow, and aspen **(ADF&G 2008b)**. Moose are most abundant in recently burned areas that have propagated dense stands of willow, aspen, and birch shrubs; on timberline plateaus; and along the major rivers of south-central and interior Alaska **(ADF&G 2008b)**. Hunters target moose throughout Alaska each fall. Black bears *(Ursus americanus)*, brown bears *(Ursus arctos)*, and wolves are major predators of calves and adult moose **(ADF&G 2008b)**. The range of moose within the ROI is shown in Figure 3–5.



Source: USFWS 2011c.

Figure 3–4. Central Arctic, Porcupine, and White Mountains Caribou Herd Distribution



Source: ADF&G 2012a; 2012b; 2012c.

Figure 3–5. Distribution of Muskoxen, Moose, and Dall Sheep Within the Poker Flat Research Range

Dall Sheep

Dall sheep *(Ovis dalli dalli)* occur in the PFRR launch corridor above timberline on ridges, dry meadows, and steep mountain slopes **(USFWS 2008f)**. Sheep are typically found adjacent to "escape terrain," which can be rocky outcrops or cliffs where predators like bears and wolves cannot easily follow. Although they generally inhabit high-elevation areas, Dall sheep are sometimes observed in rocky gorges below timberline **(ADF&G 2008c)**. Dall sheep eat grasses, sedges, broad-leafed plants, and dwarf willows **(USFWS 2008f)**. In winter, when other plants are not available, Dall sheep subsist on lichens and dry grasses **(ADF&G 2008c; USFWS 2008f)**. Movements between summer and winter feeding areas occur seasonally. Hunting is permitted only on large mature males (rams). Females are called ewes and young sheep are called lambs. Lambs are born in May or early June. Predators of Dall sheep are golden eagles *(Aquila chrysaetos)*, wolves, and coyotes *(Canis latrans)* **(ADF&G 2008c)**. Sheep numbers typically fluctuate irregularly in response to a number of environmental factors. Sheep populations tend to increase during periods of mild weather. Then, sudden population declines may occur as a result of unusually deep snow, summer drought, or other severe weather. Low birth rates, predation (primarily by wolves, coyotes, and golden eagles), and a difficult environment tend to keep Dall sheep population growth rates lower than for many other big game species **(ADF&G 2008c)**. The range of Dall sheep within the ROI is shown in Figure 3–5.

Wolves

Wolves are canids that live and hunt in packs throughout approximately 85 percent of Alaska's land area, including the PFRR launch corridor. Densities are lowest in the coastal portions of western and northern Alaska, especially after periodic rabies epidemics **(ADF&G 2008d)**. Wolves are social animals and usually live in packs that include adults and pups of the year. The average pack size is 6 or 7 animals, but much larger packs (of 20 to 30 animals) sometimes occur **(ADF&G 2008d)**. The home range of an individual pack occasionally overlaps that of a neighboring pack **(ADF&G 2008d)**. Wolves normally breed in February and March, and a litter averaging approximately 5 pups is born in May or early June. Wolf dens are usually excavated in well-drained soils to a depth of 3 meters (10 feet). Wolves are carnivores that prey primarily on moose, caribou, and Dall sheep **(ADF&G 2008d; USFWS 2008g)**. When large game is scarce, wolves rely on other prey animals like beavers *(Castor canadensis)* and snowshoe hares *(Lepus americanus)* and occasionally fish **(ADF&G 2008d)**.

Grizzly Bears

Grizzly bears are omnivorous large game animals that hibernate during the winter. Cubs are born during this hibernation period in January and February **(ADF&G 2008e)**. Long claws and a muscular shoulder-hump are adaptations that make grizzly bears (also known as brown bears) excellent at digging for roots and ground squirrels. Other food sources are salmon, carrion, berries, green vegetation, caribou calves, and moose calves. Bears may also be attracted to human camps and homes by improperly stored food and garbage, as well as domestic animals **(ADF&G 2008e)**. Due to limited food resources, grizzly bears of northern Alaska, including those within Arctic NWR, are fewer in number (one bear for every 780 square kilometers [300 square miles]), smaller in size, have lower reproduction rates, and produce cubs that mature more slowly than grizzlies in more southern populations **(ADF&G 2008e)**. Despite these disadvantages, the northern grizzly population is stable within Arctic NWR **(USFWS 2009a)**. Further south in the PFRR launch corridor is the domain of the interior grizzly. Interior grizzly bear densities are higher, with one bear every 39–65 square kilometers (15–25 square miles) **(ADF&G 2008e)**.

Black Bears

Black bears are the most abundant bear species living within the PFRR launch corridor. They are smaller in size than the grizzly, adapt to a wider range of environmental conditions (sea level to alpine), but are most often found in forested areas throughout Alaska. In Arctic NWR, the range of the black bear is limited to the south side of Brooks Range **(USFWS 2009b)**. Cubs are born in a winter hibernation den following a gestation period of 7 months **(ADF&G 2008f)**. Black bears are opportunistic feeders and may forage on green vegetation, carrion, berries, salmon, insects, and grubs and may prey on newborn moose calves and other small prey when available **(ADF&G 2008f)**. Their objective is to build up a fat reserve that enables them to survive the long, cold winter in a dormant state within their dens. Bear–human conflicts are common in urban areas in Alaska, and black bears are often attracted to garbage dumps and improperly stored food or waste **(USFWS 2009b)**.

Seasonal Considerations

Seasonality, or the presence and activity of wildlife based on time of year, is an important factor in determining species composition and relative abundance of wildlife within and around the ROI. During winter months, many wildlife species are absent or less active than in the spring, summer, and fall. Winters in Alaska are harsh, cold, and long. Many species have adapted specifically to endure these adverse conditions. Certain species of mammals, such as the black bear, endure the winter months by hibernation. Other species, such as muskoxen, develop a thick coat of fur enabling them to withstand the extreme winter conditions and remain in the Arctic throughout the year.

3.7.2.2 *Marine Mammals*

Marine mammals in the ROI live in the Beaufort Sea, which is in the eastern portion of the Arctic Ocean off of Alaska's north coast and within the PFRR launch corridor (Zone 4 and Zone 4 Arctic Extension; see Figure 3–4). The most commonly observed marine mammal species in the Alaskan Beaufort Sea are bowhead *(Balaena mysticetus)*, beluga *(Delphinapterus leucas)*, and gray *(Eschrichtius robustus)* whales; ringed *(Phoca hispida hispida)*, bearded *(Erignathus barbatus barbatus)*, and spotted *(Phoca largha)* seals; walruses *(Odobenus rosmarus)*, and polar bears *(Ursus maritimus)*. All marine mammals are protected by MMPA. The polar bear and bowhead whale are listed under the ESA as threatened and endangered, respectively. Additionally, the ringed seal and the bearded seal subspecies that have the potential to occur under the launch corridor have been proposed for listing as endangered or threatened. Accounts for these two species are included below in Section 3.7.2.7. Most marine mammal species, such as bowhead and beluga whales and ringed, bearded, and spotted seals (collectively referred to as "ice seals") are an important subsistence resource for local communities and villages.

Spotted Seals

Spotted seals are distributed along the continental shelf of the Beaufort Sea. Spotted seals are easily mistaken for harbor seals *(Phoca vitulina)*. However, only the spotted seal is regularly associated with pack ice. Spotted seal pups are born on drifting pack ice in the Bering Sea **(Boveng *et al.* 2009)**. When the pack ice melts and disperses in the Bering Sea, spotted seals migrate north toward the Beaufort Sea. As ice cover thickens with the onset of winter, spotted seals leave the Beaufort and northern Chukchi Seas and move south into the Bering Sea **(Frost *et al.* 1988)**. Hence, they are not expected to occur in the PFRR launch corridor from roughly October through spring. Spotted seals have been documented as capable of traveling long distances **(Rugh 1997)**. They have been described as extremely shy, wary, and difficult to observe, even by overflying aircraft **(Rugh 1997)**.

Pacific Walruses

Pacific walruses *(Odobenus rosmarus)* are the largest pinnipeds in the Arctic and subarctic areas. Currently, the population size of the Pacific walrus is unknown **(USFWS 2008h)**. In general, most of this population is associated with the moving pack ice year-round. Walruses spend the winter in the Bering Sea; the majority of the population summers throughout the Chukchi Sea, including the westernmost part of the Beaufort Sea. Although a few walruses may move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season, the majority of the Pacific population occurs outside of the ROI west of 155 West longitude north and west of Barrow, with the highest seasonal abundance along the pack-ice front. Solitary animals occasionally may overwinter in the Chukchi Sea and in the eastern Beaufort Sea. Predators of walruses are killer whales *(Orcinus orca)*, polar bears, and man **(USFWS 2008h)**.

Beluga Whales

The beluga whale is an Arctic and subarctic species that includes several populations in Alaskan waters. Within the PFRR launch corridor, only individuals of the Beaufort Sea stock and perhaps the eastern Chukchi Sea stock may be encountered. Some eastern Chukchi Sea animals enter the Beaufort Sea in late summer **(Suydam *et al.* 2005)**. Based on a correction factor of 2 to account for bias related to animals that may be underwater and unavailable to count during surveys, **Angliss and Allen (2009)** estimated the Beaufort Sea stock to consist of about 39,258 animals. Most of this population winters in the Bering Sea and migrates toward the eastern Beaufort Sea starting in April or May. However, some whales may pass Point Barrow as early as late March and as late as July. The spring migration routes through lanes of open water in the ice pack, known as ice leads, are similar to those of the bowhead whale. The majority of the Beaufort Sea population concentrates in the Mackenzie River estuary in Canada during July and August. The eastern Chukchi Sea stock currently is estimated to be about 3,710 whales **(Angliss and Allen 2009)**. In the Arctic, belugas feed primarily on Arctic cod *(Arctogadus glacialis)* and saffron cod *(Eleginus gracilis)*, whitefish *(Coregonus nelsonii)*, char *(Salvelinus alpinus)*, and benthic invertebrates **(Hazard 1988)**. Fall migration through the western Beaufort Sea occurs generally in September and October. Surveys of fall distribution strongly indicate that most belugas migrate offshore along the pack-ice front **(Frost *et al.* 1988; Suydam *et***

***al.* 2005)**, although large groups of whales have been observed in nearshore waters of the Alaskan Beaufort Sea. Beluga whales are an important subsistence resource of Inuit Natives in Canada and also are important locally to Inupiat Natives in Alaska.

Gray Whales

Gray whales are large baleen whales that feed on benthic organisms in or on the sea floor. Gray whales that occur along the Alaskan coast belong to the eastern Pacific stock and migrate annually from the Bering, Chukchi, and Beaufort Seas to their breeding grounds in the southern Gulf of California and Baja **(ADF&G 2008g)**. Gray whales occur regularly near Point Barrow, but historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow. Gray whales were hunted nearly to extinction by 1850 **(ADF&G 2008g)**. The north Atlantic population is extinct. The International Whaling Commission provided the gray whale partial protection in 1937 and full protection in 1947 **(ADF&G 2008g)**. This species was also protected under the ESA until 1994, when it was removed from the ESA list due to steady population increases. Since that time, the eastern north Pacific gray whale population increased to an estimated maximum of 29,758 in 1997–1998 **(Rugh *et al.* 2005)**.

Seasonal Consideration

Spotted seals are absent from the ROI during the winter, walruses and beluga whales may move through the area during the summer, and gray whales may be present during the winter, if at all.

3.7.2.3 *Birds*

Resident birds live in the same location for the entire year, where they hatch, fledge, molt, breed, nest, and raise their young. Birds that are migratory spend a shorter amount of time in the PFRR launch corridor than the residents. Typically, migratory birds spend time in Arctic NWR or Yukon Flats NWR in the summer months to rest, molt, breed, and/or nest. Birds that include Alaska in their migration path travel mostly long distances. For example, the bar-tailed godwit *(Limosa lapponica)* flies more than 11,000 kilometers (7,000 miles) nonstop to New Zealand; the northern wheatear *(Oenanthe oenanthe)* migrates across Asia to spend its winter in Africa; and the Dunlin's *(Calidris alpina)* winter destination is Japan **(USFWS 2008i)**.

Areas in which migratory or resident birds congregate are also ecologically significant. Forty-six species of seabirds, totaling over 80 million individuals, breed in Alaska and the Russian Far East. During the summer months, along the coast of the Beaufort Sea and within Zone 4AX of the PFRR launch corridor, colonies of sea birds, including glaucous gulls *(Larus hyperboreus)*, Arctic terns *(Sterna paradisaea)*, and Sabine's gulls *(Larus sabini)*, return from wintering grounds to congregate in breeding colonies. In the fall, seabirds return to their wintering grounds in areas such as coastal Washington, Oregon, and California to escape the severe Alaskan winters **(USFWS 2011f)**.

Approximately 36 species of waterfowl, totaling over 20 percent of the entire U.S. population, breed in Alaska. Duck species, such as the canvasback *(Aythya valisineria)*, northern pintail *(Anas acuta)*, and redhead *(Aythya americana)*, congregate in areas within PFRR, including the

Yukon River Delta, during the summer months to breed, and, like the seabirds, migrate south in the fall **(USFWS 2011g)**.

Shorebirds also congregate in large numbers during the breeding season. Due to its size, northerly latitude, and vast amount of shoreline, Alaska hosts more breeding shorebirds than any other state. Seventy-one species of shorebirds breed in Alaska for a total of between 7 and 12 million individuals, or approximately 50 percent of the world's shorebird population. Not all shorebird species nest along the coastal regions of Alaska. Species such as the semipalmated sandpiper *(Calidris pusilla)*, black-bellied plover *(Pluvialis squatarola)*, and bar-tailed godwit also occur in large numbers farther inland in wet marshy habitats such as the Copper River Delta. A vast quantity of suitable habitat for shorebird exists within the ROI. The shoreline of the Yukon River Delta has an especially large and diverse shorebird population. As with the previous two groupings, seabirds and waterfowl, shorebirds also migrate south during the fall **(USFWS 2011h)**.

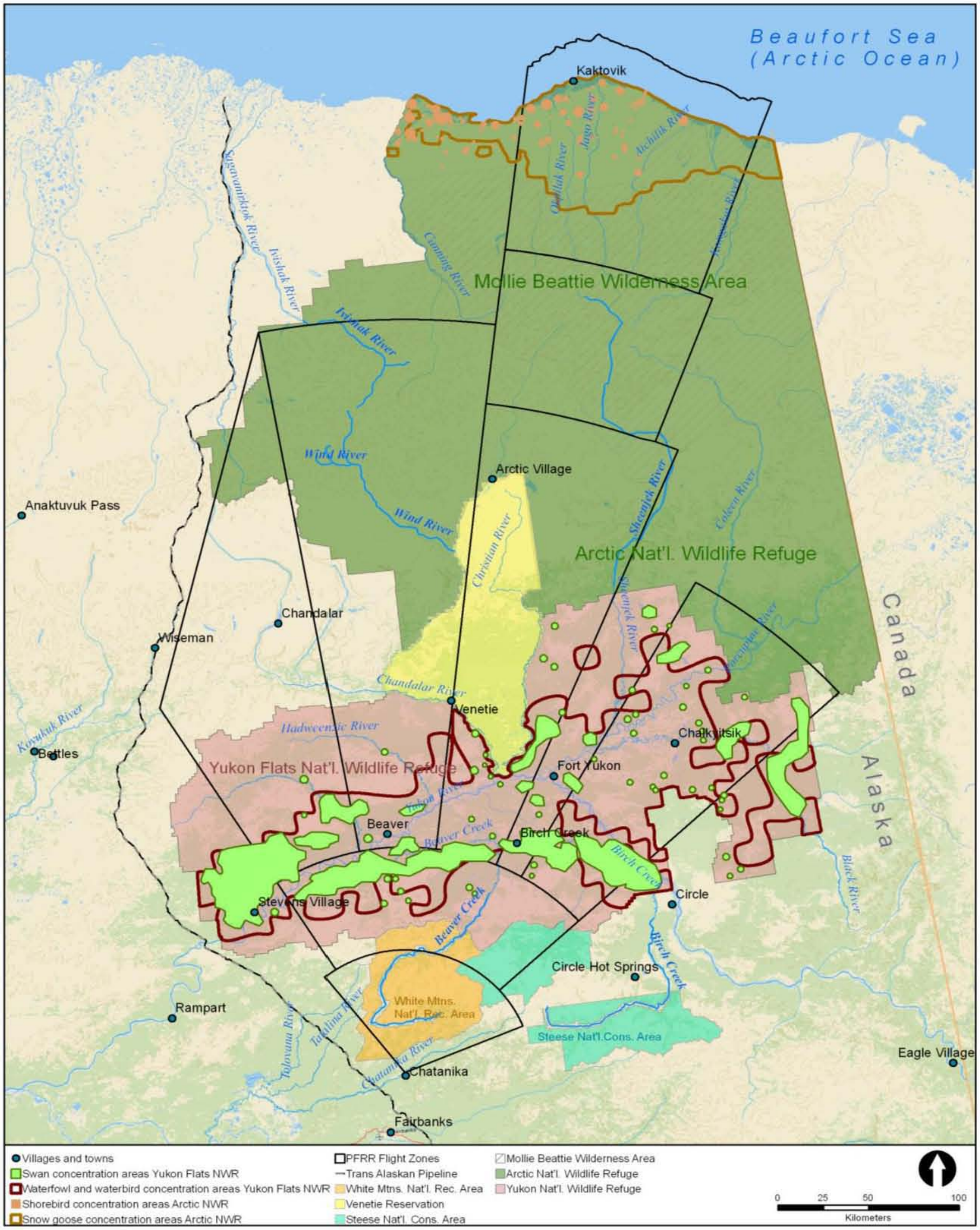
Terrestrial songbirds such as warblers, flycatchers, and thrushes also breed in Alaska and migrate south in the winter, but in general do not congregate in such large groups or colonies **(USFWS 2011h)**.

Several species of raptor also occur within the PFRR launch corridor. Common breeding species include red-tailed hawk, Cooper's hawk, and Swainson's hawk. Less common species include the gyrfalcon and two subspecies of peregrine falcon: the Arctic and American. The bald eagle and osprey are commonly found along coastal areas in the northern part of the PFRR launch corridor **(USFWS 2011g)**.

Certain areas within the ROI, such as the Arctic NWR and Yukon Flats NWR, contain especially high concentrations of birds, including waterfowl and shorebirds. **Figure 3–6** includes these two groupings as an example to illustrate locations with particularly high bird concentrations. Specifically, Figure 3–6 shows snow goose and shorebird concentrations within Arctic NWR and waterfowl and swan concentrations within Yukon Flats NWR.

Seasonal Considerations

The majorities of the bird species present within the PFRR launch corridor are migratory and are present only during the summer months. During winter, the abundance and number of species decline within the ROI. Sensitivity of bird species to disturbance is greatest during the breeding season (summer) and when congregated at rest during migration.



Source: **USFWS 2008j, 2011c.**

Figure 3–6. Waterfowl and Shorebird Bird Congregation Areas Within Arctic and Yukon Flats National Wildlife Refuges

3.7.2.4 *Fish*

A total of 42 fish species have been documented within the waters of the PFRR launch corridor. These fish can be classified in terms of three principal life histories: freshwater, diadromous, or marine. By definition, freshwater species spend their entire lives in rivers and lakes of the North Slope and generally avoid saline waters. In practice; however, most freshwater species on the North Slope, such as Arctic grayling *(Thymallus arcticus)* and round whitefish *(Prosopium cylindraceum)*, exhibit annual movements downriver to low-salinity estuarine and nearshore waters, particularly during early summer, when freshwater runoff to coastal habitats is at a peak **(Hemming 1993; Moulton and Fawcett 1984)**.

Fish distribution is dependent on water quality factors, including dissolved oxygen levels, temperature, turbidity, depth, current velocity, and substrate type **(USFWS 2010a)**. Freshwater fish in Yukon Flats NWR typically overwinter in deepwater areas of rivers and lakes and travel short distances to spawn in the open-water season **(USFWS 2010a)**. Burbot *(Lota lota)* are the only exception, which spawn in January and February beneath the ice.

The term diadromous is used to describe fish species that migrate between freshwater and estuarine or marine habitats on an annual basis **(Gallaway and Fechhelm 2000)**. The most important of these are anadromous species, which spend part of their lifecycle in the marine environment and swim upstream to spawn in freshwater habitats. Anadromous species include fish such as salmon that leave marine waters to return to the freshwater habitats to spawn where they were born. In the Pacific Northwest, some stocks of Chinook and Coho salmon are considered threatened or endangered, but no Alaskan stocks have yet been listed **(USFWS 1990)**. However, BLM considers the Beaver Creek stock of Chinook to be a sensitive species **(USFWS 2010a)**. A sensitive species is one that can easily become threatened or endangered. The northern extent of the range of some species, including Pacific salmon, has been expanding, and some salmon runs have been established in streams that drain into the western Beaufort Sea (outside of the launch corridor boundaries) **(Craig and Haldorson 1986; Moulton 2001)**. This trend is coincidental to global climate change and an Arctic warming trend. Other diadromous species, such as Dolly Varden *(Salvelinus malma malma)*, Arctic cisco *(Coregonus autumnalis)*, broad whitefish *(Coregonus nasus)*, and least cisco *(Coregonus sardinella)*, migrate back and forth each summer between upriver overwintering areas and feeding grounds in Beaufort Sea coastal waters. This life strategy takes advantage of prey abundance in the nearshore zone that can be nine times higher than freshwater habitats **(Craig 1989)**.

Most marine species inhabit deeper offshore waters are either rarely reported in the North Slope coastal zone or move inshore following breakup of shorefast ice. Arctic cod, fourhorn sculpin, and Arctic flounder, for example, specifically migrate into shallow, low-salinity coastal waters and estuaries during summer **(Craig 1989)**. Very little is known about marine fish distribution, abundance, diversity, or habitat use pattern in the winter.

Marine species of the Beaufort Sea nearshore waters are sporadically distributed and typically occur in very low numbers during summer **(Fechhelm *et al.* 2006)**. The exceptions are Arctic cod, Arctic flounder *(Liopsetta glacialis)*, and fourhorn sculpin *(Myoxocephalus quadricornis)*. Arctic flounder and fourhorn sculpin migrate into brackish coastal habitats during summer to feed, and may travel considerable distances up rivers. The open-water season of the Beaufort Sea is typically from mid-July to mid-October, meaning that the sea is covered with ice for the majority of the year. The Alaska Native Village of Kaktovik is situated on the shore of the Beaufort Sea in Arctic NWR. Fish is an important subsistence resource for Kaktovik, and the people fish the rivers and sea surrounding them with set nets and seines **(Pederson and Linn 2005)**.

Some of the fish in the launch corridor regions have commercial, recreational, or subsistence uses (e.g., salmon, cisco, Dolly Varden, whitefish, cod, herring, grayling, smelt, pike). Fish are especially important to Alaska Natives because, in many cases, they are available throughout the entire year. During years of poor salmon or caribou harvest, resident fish species are particularly vital as a subsistence food source. They are often captured beneath the frozen surface of lakes, streams, and the ocean. Recreationists enjoy sport fishing in the summer and ice-fishing in the winter for lake- and stream-dwelling freshwater fish.

Seasonal Considerations

The most important seasonal consideration for this analysis is the presence of ice. When water bodies, including lakes, rivers, and the ocean, are frozen, fish are isolated from launch or recovery activities by the ice layer. During summer, many species move to shallow water and upstream to feed and/or breed and are more easily captured by humans and wildlife under these conditions (*e.g.,* salmon). Fish species would have some minimal chance of coming into contact with project-related activities (*e.g.,* recovery activities) during the summer season.

3.7.2.5 *Fishery Management Plans and Essential Fish Habitat*

The Fishery Resource Management Plan (FMP) for the Fish Resources of the Arctic Management Area was recently approved in August 2009 by the U.S. Secretary of Commerce **(74 FR 56734)**. This plan presently prohibits commercial fishing in the Arctic waters of the Chukchi and Beaufort Seas until more information is available to support sustainable fisheries management. Only target species are part of the fishery management unit for this FMP, requiring status determination criteria and Essential Fish Habitat (EFH) descriptions. Target species under the Arctic FMP are Arctic cod, saffron cod, and snow crab *(Chionoecetes opilio)*. All other finfish and invertebrates are classified as “ecosystem component species” until further information is available. Pacific salmon and Pacific halibut are part of the ecosystem component for this FMP only for purposes of managing bycatch of these species in any commercial fishery that may develop in the future in the Arctic Management Area. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) **(P.L. 94-265)** mandates identification and conservation of EFH for managed species. The National Marine Fisheries Service (NMFS) and North Pacific Fishery Management Council have issued the *Final Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska* **(NOAA 2005)**. The definition of EFH is those waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity. Any new FMPs must include EFH designations. To protect EFH, certain EFH habitat conservation areas may be designated. A habitat conservation area is an area where fishing restrictions are implemented for the purposes of habitat conservation. No EFH habitat conservation areas have been designated in the Arctic Management Area except those for Pacific salmon under MSA. If commercial fishing is authorized, EFH habitat conservation measures may be included in the amended FMP.

Salmon EFH includes all those freshwater streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon. Marine EFH for the salmon fisheries in Alaska includes all estuarine and marine areas used by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. Exclusive Economic Zone. This habitat includes waters of the continental shelf (to the 200-meter [660-foot] isobaths). In the deeper waters of the continental slope and ocean basin, salmon occupy the upper water column, generally from the surface to a depth of about 50 meters (160 feet). Chinook and chum salmon *(Oncorhynchus keta)* use deeper layers, generally to about 300 meters (980 feet), but on occasion to 500 meters (1,600 feet) **(NOAA 2005)**.

3.7.2.6 *Subsistence Fisheries*

The Arctic FMP does not apply to subsistence fishing. Subsistence fisheries in Alaska are managed by the state or through the Federal Subsistence Board, if occurring on Federal lands. Many of these fisheries take place primarily in state waters. Subsistence fishing is an important sociocultural activity in Arctic waters. Because the Arctic FMP governs commercial fishing, the Arctic FMP would not affect these subsistence fisheries. Thus, the current commercial fishing ban does not apply to subsistence fisheries that are exclusively coastal in nature and centered on settlements like Wainwright, Barrow, Kaktovik, and Nuiqsut along Alaska's northern coast and nearshore waters. Subsistence fishermen harvest freshwater, marine, and anadromous fish in the area at differing times of the year, although the majority is harvested in summer and fall. Capelin *(Mallotus villosus)*, char, Arctic and saffron cod, Arctic grayling *(Thymallus arcticus)*, salmon, sculpin, trout, and whitefish are harvested. Subsistence fishing harvest represents a consistent year-to-year yield when compared to other subsistence resources (e.g., caribou), which may fluctuate widely on an annual basis. This consistency increases the importance of subsistence fisheries to the residents of native villages. Subsistence activities are discussed further in Section 3.10.

3.7.2.7 *Listed, Proposed, and Candidate Species under the U.S. Endangered Species Act*

Table 3–13 lists the federally listed, proposed, and candidate species that may occur under the PFRR launch corridor **(USFWS 2011i)**. Brief accounts of these species are provided following the table. Note that there are no federally listed, proposed, or candidate plant species known to be located at the PFRR launch site. Lists of federally listed, proposed and candidate species potentially in the PFRR launch corridor were provided by USFWS **(USFWS 2011j)** and NOAA Fisheries **(NOAA 2011)** in response to NASA's requests. This section addresses the species identified by those agencies.

Table 3–13. Federally Listed, Proposed, and Candidate Species with the Potential to Occur Under the Poker Flat Research Range Launch Corridor

Common Name	Scientific Name	ESA Listing Status	Potential Seasonal Occurrences[a]
Bowhead whale	*Balaena mysticetus*	Endangered	Summer[b]
Polar bear	*Ursus maritimus*	Threatened	Year-round
Ringed seal	*Phoca hispida hispida*	Proposed	Year-round
Bearded seal	*Erignathus barbatus barbatus*	Proposed[c] (Beringia DPS)	Summer
Spectacled eider	*Somateria fischeri*	Threatened	Accidental[d]
Steller's eider (Alaska breeders)	*Polysticta stelleri*	Threatened	Accidental
Yellow-billed loon	*Gavia adamsii*	Candidate	Summer

a. Seasonal occurrence identifies the times of the year when the species would most likely be encountered in the PFRR launch corridor.
b. "Summer" for this analysis is May through September.
c. The Beringia DPS, the distribution of which includes the Beaufort Sea area under the PFRR launch corridor, was proposed for listing as endangered on December 10, 2010.
d. "Accidental" refers to species having unpredictable presence in the PFRR area.

Key: DPS=distinct population segment.
Source: USFWS 2011i.

Under the ESA, endangered species are determined to be in danger of extinction throughout all or a significant portion of their range. Threatened species are determined to be likely to become endangered within the foreseeable future throughout all or a significant portion of their range. Proposed species are species for which a proposed rules to list the species as either threatened or endangered has been published in the *Federal Register*. Candidate species are species for which USFWS or NOAA Fisheries Service has indicated it has sufficient information on biological vulnerability and threat(s) to support proposals as threatened or endangered. Delisted species are species that have been removed from the list of threatened and endangered species. USFWS and NOAA Fisheries monitor delisted species for a period of at least 5 years following delisting. The Alaska Department of Fish and Game (ADF&G) also maintains a list of special status species. Although the Federal and Alaska lists have several species in common, the State of Alaska listings are specific to only Alaska and are discussed separately at the end of this section.

Bowhead Whales

The western Arctic stock of bowhead whales *(Balaena mysticetus)* was listed as endangered on June 2, 1970, and has been on the endangered species list since then. Because of the ESA listing, the stock is classified as a depleted and a strategic stock under MMPA **(Angliss and Allen 2009)**. However, the western Arctic bowhead whale population appears to be healthy and growing under a managed hunt and has recovered to historic abundance levels. NMFS will use criteria developed for the recovery of large whales in general **(Angliss *et al.* 2002)** and bowhead whales in particular in the next 5-year ESA status review to determine if a change in listing status is needed **(Shelden *et al.* 2001)**.

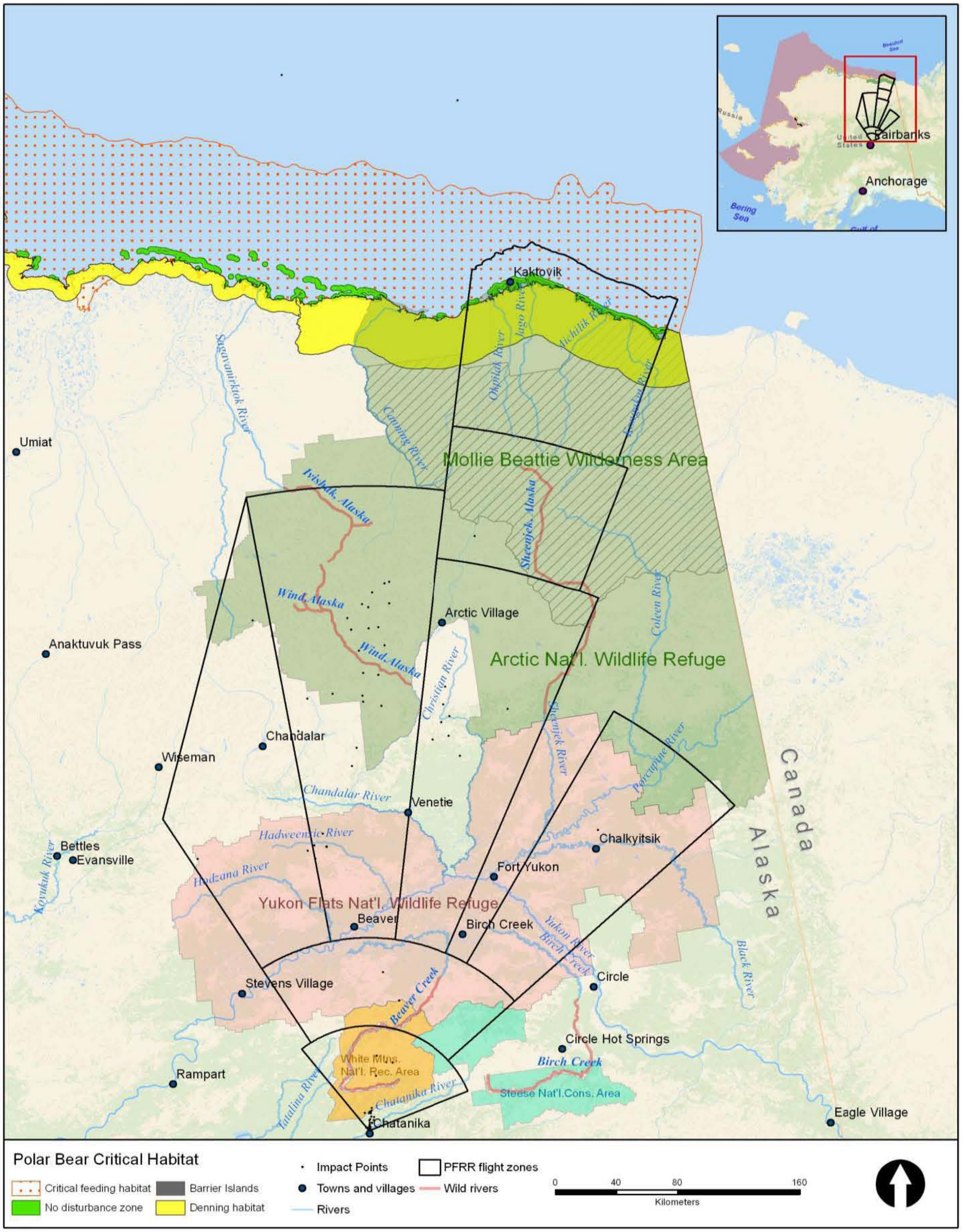
The bowhead whale spends its entire life in the Arctic. There are four stocks recognized, of which the Bering-Chukchi-Beaufort stock occurs within the PFRR launch corridor. Based on a bowhead whale census in 2001, the population growth rate was estimated to be about 3.4 percent and the estimated population size, 10,470 **(George *et al.* 2004)**, revised to 10,545 by **Zeh and Punt (2005)**. Most of the western Arctic bowhead whales migrate annually from wintering areas in the northern Bering Sea, through the Chukchi Sea in the spring, and into the Beaufort Sea, where they spend the summer. In autumn, they migrate through nearshore and offshore waters of the Beaufort Sea to return to their wintering grounds in the Bering Sea. Alaskan coastal villages along this migratory route, mainly Kaktovik, participate in traditional subsistence hunts of these whales **(Angliss and Allen 2009)** along the coast of the Beaufort Sea and within the PFRR launch corridor. Bowheads appear to migrate farther offshore during heavy-ice years and nearer shore during years of light sea ice **(Treacy *et al.* 2006)**.

Polar Bears

Polar bears *(Ursus maritimus)* are classified as marine mammals because of their dependence on sea ice; as such, they are protected under MMPA, as well as the ESA. On May 15, 2008, USFWS listed the polar bear as threatened throughout its range under the ESA **(73 FR 28212)**. The listing is in part a response to increased concerns about the effect of climate change on sea ice. Sea ice provides a hunting platform for polar bears and has been in decline in recent years. A polar bear's diet is made up almost exclusively of marine mammals, mainly ice seals that also depend on sea ice habitat. Additionally, sea ice provides a portion of winter denning habitat for pregnant female polar bears. On November 24, 2010, USFWS announced the designation of 484,000 square kilometers (187,000 square miles) of polar bear critical habitat containing sea ice, terrestrial denning habitat, and barrier islands. The designated critical habitat occurs under the northern portion of the PFRR launch corridor (see **Figure 3–7**). The critical habitat includes the Beaufort Sea and land within 32 kilometers (20 miles) inland from the Beaufort Sea coast within the PFRR launch corridor. For purposes of this EIS, USFWS assumes polar bears may occur up to 40 kilometers (25 miles) inland from the Beaufort Sea coast **(USFWS 2011k)**.

Figure 3–7 also shows impact points from NASA SRP launches from PFRR from 1994 through 2010. No spent stages or payloads are predicted to have landed within this designated critical habitat.

Polar bears have a circumpolar Arctic distribution and are the top predator in the Arctic ecosystem. Polar bears are also the largest land carnivore in the world. Polar bear movements are influenced by sea ice conditions and follow a predictable seasonal pattern. In July and August, polar bears move offshore as the pack ice recedes. In the case of the SBS and CBS populations, polar bears may move hundreds of miles to stay with the ice during summer. From August through October, polar bears hunt ringed seals (their most important prey species) near shore in areas of unstable ice and leads between ice floes. From November to June, male polar bears remain on offshore ice. Years with less sea ice seem to result in bears being on land for longer periods of time.



Note: To convert kilometers to miles, multiply by 0.6214.

Source: SAIC 2011; USFWS 2011j.

Figure 3–7. Designated Critical Habitat for Polar Bears, Showing PFRR Launch Zones and Predicted Impact Points for Past PFRR Launches Between 1994 and 2010

Mating occurs from March to May **(Ramsay and Stirling 1986)**. Approximately 50 percent of females den on drifting pack ice from November until April, although evidence suggests that this number is decreasing with recent changes in sea ice extent and distribution **(Fischbach *et al.* 2007)**. The remaining females that are in reproductive condition den on land from November through April, then move offshore.

November through April is the most sensitive period of the year for polar bears. Dens are dug in snow drifts in areas of shallow relief along sea ice pressure ridges, creek and stream banks, river bluffs, and shorelines. Cubs are born in December and continue to develop in the den until April. Dens have been located up to 40 kilometers (25 miles) inland in landscape features that trap drifting snow in sufficient depth to allow a female polar bear to dig a den **(Durner *et al.* 2006)**. The highest density of land dens in Alaska occurs along the coastal barrier islands of the eastern Beaufort Sea and within Arctic NWR **(Angliss and Allen 2009)**.

Denning females are sensitive to disturbance and may abandon cubs if disturbed. Cubs are very vulnerable at this stage, so protection of the maternal den habitat is vital to polar bear conservation **(Angliss and Allen 2009)**. The results of surveys for polar bears confirm that large numbers of polar bears aggregate around Barter Island (on which Kaktovik is located) and Cross Island (west of the ROI between Prudhoe Bay and Point Barrow), probably due to the presence of hunter-harvested bowhead whale remains, which provide an alternate food source for polar bears.

Ringed Seals

Ringed seals *(Phoca hispida)* have a circumpolar distribution and are year-round residents of the Beaufort Sea, where they are the most commonly encountered seal species in the area. No reliable population size estimate of the Alaska ringed seal stock is currently available **(Angliss and Allen 2009)**. Ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1–1.5 million **(Frost 1985)** to 3.3–3.6 million **(Frost *et al.* 1988)**. **Frost and Lowry (1981)** estimated the population in the Alaskan Beaufort Sea to be 80,000 during the summer and 40,000 during the winter. More recent estimates based on extrapolation from aerial surveys and on predation estimates for polar bears **(Amstrup 1995)** suggest an Alaskan Beaufort Sea population of approximately 326,500 animals. NOAA Fisheries is considering listing the Alaska stock of ringed seals species under the ESA due to the potential loss of seal habitats resulting from current warming trends. On December 10, 2010, NOAA Fisheries published a proposed rule to list three subspecies of the ringed seal as threatened under the ESA. This proposed listing includes the Arctic subspecies *(Phoca hispida hispida)*, the distribution of which includes the Beaufort Sea. Ringed seal densities depend on food availability, water depth, ice stability, and distance from human disturbance. Seal densities reflect changes in the ecosystem's overall productivity in different areas **(Stirling and Oritsland 1995)**. When sexually mature, they establish territories during the fall and maintain them during the pupping season (time of year seals give birth to seal pups). Pups are born in late March and April in lairs that seals excavate in snowdrifts and pressure ridges. During the breeding and pupping season, adults on shorefast ice (floating ice attached to land) usually move less than individuals in other habitats. In this habitat, they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. During nursing (4 to 6 weeks), pups usually stay in the birth lair. This species is a major resource harvested by Alaskan subsistence hunters. Ringed seal is also the chief prey species for polar bears.

Bearded Seals

Bearded seals *(Erignathus barbatus)* are the largest of Alaska's seals, weighing up to 340 kilograms (750 pounds). Bearded seals are found throughout the Arctic Ocean and usually prefer areas of less stable or broken sea ice, a zone where breakup occurs early **(Cleator and Stirling 1990)**. Most of the 300,000 to 450,000 bearded seals estimated to occur in the Alaskan outer continental shelf area are found in the Bering and Chukchi Seas **(USDOI 1996)**. Reliable estimates of the abundance of bearded seals in Alaska Beaufort Sea waters currently are unavailable, although bearded seals are reported annually during aerial surveys for other marine mammals. Seasonal movements of bearded seals are directly related to water depth and the advance and retreat of sea ice **(Boveng *et al.* 2009)**. During winter, most bearded seals in Alaskan waters are found in the Bering Sea. Favorable conditions are more limited in the Chukchi and Beaufort Seas, and consequently, bearded seals are not abundant there during winter. Pupping takes place on the ice from late March through May, mainly in the Bering and Chukchi Seas, although some pupping might take place in the Beaufort Sea. Bearded seals do not form herds, but sometimes form loose groups. Bearded seals are a main subsistence resource and a highly valued food of subsistence hunters. The form of bearded seal that occurs in the Beaufort Sea under the PFRR launch corridor is part of the Beringia Distinct Population Segment of *Erignathus barbatus barbatus*, which was proposed for listing as endangered on December 10, 2010.

Spectacled Eider

Spectacled eider *(Somateria fischeri)* is known as a rare breeder and uncommon visitor along Alaska's north coast. Nesting and breeding typically occur to the west of the PFRR launch corridor, although the historical range extended along the Arctic coastal plain, including the coastal portion of the PFRR launch corridor, nearly as far east as the Canadian border **(USFWS 2011l)**. Critical habitat designated for this species is far outside the boundaries of the PFRR launch corridor. Spectacled eiders winter at sea in flocks **(USFWS 2011l)**.

Steller's Eiders

Although formerly considered locally common at a few sites on both the Yukon-Kuskokwim Delta in western Alaska and the Arctic coastal plain of northern Alaska, Steller's eiders *(Polysticta stelleri)* have nearly disappeared from most nesting areas in Alaska **(USFWS 2011m)**, and the Alaska population is listed as threatened. Of the world breeding population of Steller's eiders, most nest in Russia. The nearest known nesting area is located to the west of the ROI at Prudhoe Bay. Molting and wintering is in the southern Alaska from the eastern Aleutians to the lower Cook Inlet.

Yellow-Billed Loon

The yellow-billed loon *(Gavia adamsii)* is listed as a candidate species. It breeds in low densities within Arctic NWR and may also migrate through the region. According to the list of species provided by USFWS **(USFWS 2011k)**, no listed species or designated critical habitats occur in Yukon Flats NWR, Steese NCA, or White Mountains NRA.

The American peregrine falcon *(Falco peregrinus anatum)* was delisted in 1999, the Arctic peregrine falcon *(Falco peregrinus tundrius)* was delisted in 1994, and the gray whale *(Eschrichtius robustus)* was delisted in 1993.

3.7.2.8 *Endangered Species, Species of Special Concern, and Fish Stocks of Concern Recognized by the Alaska Department of Fish and Game*

ADF&G maintains a list of special status species, including endangered species, species of special concern, and fish stocks of concern **(ADF&G 2011a)**. Although believed to be extinct, the state-listed endangered Eskimo curlew's *(Numenius borealis)* range in eastern Alaska could potentially overlap with the ROI. No other state-listed endangered species occur within the ROI or surrounding area. Several state species of special concern have the potential to occur within the ROI, including the spectacled eider, bowhead whale, and the blackpoll warbler (*Dendroica striata*). The Yukon River Delta subspecies of Chinook salmon is the only state fish stock of concern with the potential to occur within the ROI.

3.7.2.9 *Sensitive Species Recognized by the Bureau of Land Management*

BLM studies all animal species that thrive on BLM lands. When a particular animal species becomes in danger of rapidly dwindling to extinction, the BLM lists that animal on a BLM Sensitive Species List. National policy directs BLM state directors to designate BLM sensitive species in cooperation with the State fish and wildlife agency (BLM Manual 6840). The sensitive species designation is normally used for species that occur on BLM public lands and for which BLM has the capability to significantly affect the conservation status of the species through management **(USDOI 2012b)**.

The American peregrine falcon nests in the region, as does the bald eagle; both are BLM sensitive species. Other BLM-sensitive species with potential to be found in the PFRR launch corridor include: Canada lynx (*Lynx canadensis*), trumpeter swan (*Cygnus buccinator*), grey-cheeked thrush (*Catharus minimus*), olive-sided flycatcher (*Contopus cooperi*), and blackpoll warbler. However, most species are not present during the rocket launching period. Canada lynx occur in the area during all seasons. No BLM-sensitive plant species are known to occur in the White Mountains NRA or Steese NCA **(USDOI 2007)**.

Bald Eagle

The bald eagle is a year-round resident within Alaska and PFRR. Although the species may nest in preferred habitat throughout PFRR, there is a particularly high concentration of nesting individuals in the northern portion of the range, especially along coastal regions. Bald eagles tend to congregate in large groups during the winter months in aquatic habitat that remains ice-free. Although bald eagle numbers (both in Alaska and globally) fell to a historical low in the 1970s' following widespread use of certain pesticides, specifically DDT, the population appears to be recovering to pre-decline numbers following the ban of DDT, as well as recovery efforts from agencies such as USFWS, BLM, and ADF&G **(USFWS 2011h)**.

American Peregrine Falcon

The American peregrine falcon occurs in and nests within PFRR. Typically this species nests in crevices found along high cliff walls and river bluffs. However, ground nesting has also been documented along the north slope of Alaska. This species is known to migrate long distances and spend winters as far south as South America. However, in recent years, it has been observed that certain segments of the Alaskan population have spent the entire year (both breeding and non-breeding seasons) in Alaska. As with the bald eagle, population numbers decreased in the 1970s' due to pesticide use. Similarly, the population appears to be recovering to pre-decline numbers due to the banning of DDT and multi-agency recovery efforts **(ADF&G 2012d; USFWS 2011n)**.

Trumpeter Swan

The trumpeter swan occurs and nests within PFRR. The species breeds in coastal regions from Cook Inlet south to the Chilkat Valley, as well as in the interior forested wetlands. Typically, wintering trumpeter swans prefer freshwater wetlands, bays, and estuaries from Cook Inlet to the Columbia River in Washington. In the early 1900s, trumpeter swans in Alaska, as well as globally, experienced a severe population decline due to exploitation of market hunters. Since that time, the population appears to have increased, although it is still listed as a sensitive species in many locations throughout the United States **(USFWS 2008j)**.

Grey-Cheeked Thrush

The grey-cheeked thrush is known to occur and breed within PFRR. In Alaska it tends to occur in coniferous woods consisting mostly of white spruce, black spruce, and some tamarack. The grey-cheeked thrush is not a winter resident in Alaska and typically migrates south to warmer climates, *i.e.,* Venezuela and Columbia. Although the global population experienced historical declines in the mid-twentieth century, the exact causes are not known, but may include nest predation, loss of habitat, and collisions with manmade structures **(NPS 2012)**.

Olive-Sided Flycatcher

The olive-sided flycatcher is known to occur and breed within Alaska and PFFR. Preferred breeding habitat typically consists of openings and edges in coniferous forest habitats. Since the 1960s, this species has experienced a precipitous decline in numbers. Although the exact cause of the population decline is not known, habitat loss through fire suppression and habitat fragmentation are potential factors. Typically, olive-sided flycatchers winter in Panama and the northern Andes from northern Venezuela to western Bolivia, with the highest densities in Colombia **(BSI 2007)**.

Blackpoll Warbler

The blackpoll warbler occurs and breeds in Alaska and within PFRR. Preferred habitat, including nesting habitat, includes tall shrubs (riparian woodland) or in coniferous or deciduous forest or woodland mainly in western and northern Alaska. The species has experienced a population decline in the past 40 years, which is thought to be a result of tropical deforestation in areas where the blackpoll warbler winters in South America **(USGS 2010)**.

Canada Lynx

The Canada lynx is a year-round resident mammal of Alaska and also PFRR. It is the only cat native to the state. This medium-sized predator prefers remote habitats and ranges over the entire state, except the Aleutian Islands, Kodiak archipelago, the islands of the Bering Sea, and some islands of Prince William Sound and Southeast Alaska. Although the species is not commonly reported during the winter months, it is commonly seen during long periods of summer daylight, especially during years that they are abundant **(ADF&G 2008h)**.

3.8 LAND USE AND RECREATION

The ROI for land use and recreation is defined as the area within the PFRR launch site and launch corridor. Portions of the White Mountains NRA, Steese NCA, Arctic NWR, Yukon Flats NWR, and Alaska state lands are located within the PFRR launch corridor. Recreational opportunities are available within these federally and state-managed areas. Alaska Native-owned lands are not open to use by the general public and are not included in the recreation ROI.

3.8.1 Poker Flat Research Range Launch Site

The PFRR launch site occupies approximately 2,100 hectares (5,200 acres) of land directly south of the Chatanika River within the Fairbanks North Star Borough and include the Lower, Middle, and Upper Ranges **(NASA 2000a)** (see Chapter 2, Figures 2–12, 2–17 and 2–18). The PFRR launch site is zoned as Educational Exempt.

3.8.2 Poker Flat Research Range Launch Corridor

The PFRR launch corridor encompasses a vast portion of interior and northern Alaska. **Table 3–14** lists the approximate areas of land ownership within the PFRR launch corridor.

Table 3–14. Lands Within Poker Flat Research Range Launch Corridor

Managed Land	Total Area (hectares)	Area Within Poker Flat Research Range (hectares)
U.S. Department of the Interior		
White Mountains National Recreation Area	376,000	354,000
Steese National Conservation Area	461,000	125,000
Arctic National Wildlife Refuge	8,030,000[a]	4,900,000[b]
Yukon Flats National Wildlife Refuge	4,500,000	3,300,000
Villages		
Beaver	96,000	96,000
Birch Creek	93,000	53,000
Chalkyitsik	150,000	150,000
Fort Yukon	109,000	47,000
Kaktovik	60,000	60,000
Stevens Village	90,000	10,000
Other		
Arctic Slope Regional Corporation	2,040,000	4,600
Doyon Limited	3,900,000	560,000
Venetie Indian Corporation and Neets'ai Corporation	790,000	790,000
State of Alaska	47,000,000	1,200,000
Private	84,000	1,040
Total	**60,000,000**	**12,000,000**

a. Includes all of Mollie Beattie Wilderness Area (2.9 million hectares [7.2 million acres]).
b. Includes portion of Mollie Beattie Wilderness Area within PFRR (1.6 million hectares [4 million acres]).
Note: To convert hectares to acres, multiply by 2.4710.
Source: SAIC 2011.

3.8.2.1 *White Mountains National Recreation Area*

White Mountains NRA is located approximately 97 kilometers (60 miles) northwest of Fairbanks. It is bounded on the east by Steese NCA and on the north by Yukon Flats NWR. White Mountains NRA is administered by BLM. ANILCA **(P.L. 96-487)** directs that White Mountains NRA is to be administered to provide for public outdoor recreational use and for the conservation of scenic, historic, cultural, and wildlife values and for other uses if they are compatible or do not significantly impair the previously mentioned values **(USDOI 1986a)**. The overall management strategy for White Mountains NRA is to provide for a variety of public outdoor recreation opportunities, emphasizing existing primitive and semi-primitive values; to protect and/or improve the water quality of Beaver Creek National Wild River and its tributaries; and to provide for multiple uses of other resource values that are compatible with the recreation goals. The primary recreation attractor in White Mountains NRA is Beaver Creek National Wild River **(USDOI 1986a)**. As shown in Table 3–14, White Mountains NRA encompasses approximately 376,000 hectares (930,000 acres), and approximately 354,000 hectares (880,000 acres) of White Mountains NRA are located within the PFRR launch corridor.

Recreational activities within the White Mountains NRA during the summer include panning for gold, fishing, hiking, off-highway vehicle use, and camping. BLM manages over 64 kilometers (40 miles) of summer trails, including the Summit and Quartz Creek Trails. Thirteen public recreation cabins are located within the White Mountains NRA. The cabins are accessed most easily during the winter, but a few cabins can be reached during the summer by foot, mountain bikes, four-wheelers, boats, and airplanes. The cabins are open year-round, with most visitors using the cabins February through April **(USDOI 2012c)**. Most of the Beaver Creek Wild River is located within the White Mountains NRA. Beaver Creek is a popular destination for river adventurers. White Mountains NRA is open to sport hunting. Game species include moose, caribou, black bear, grizzly bear, sheep, wolf, and wolverine. A portion of White Mountains NRA is open to the use of motorized vehicles during designated time periods. Activities during the winter include skiing, snowshoeing, dog sledding, skijoring (cross-country skiing while being pulled by dogs), snowmobiling, and winter mountain biking **(USDOI 2011b, 2011c)**.

White Mountains NRA receives roughly 35,000 visits per year, with many of the visitors being repeat users. Peak use periods include early March through mid-April for winter activities, based on longer days and warmer temperatures, and late summer for activities such as berry picking and hunting. Unlike many other areas around Alaska, White Mountains NRA does not have a large targeted salmon run and is not located on a primary travel and tourism route **(USDOI 2012a)**.

3.8.2.2 *Steese National Conservation Area*

Steese NCA is located approximately 160 kilometers (100 miles) northeast of Fairbanks and is administered by BLM. Steese NCA was created by ANILCA in 1980 and includes the Birch Creek Wild and Scenic River, crucial caribou calving grounds and home range, and Dall sheep habitat. Steese NCA is split into the North and South Units, located on either side of Steese Highway (Alaska Route 6). Pinnell Mountain National Recreation Trail skirts the edge of the North Unit. Various land uses are allowed in Steese NCA; however, it is managed to protect its scenic, scientific, cultural, and other resources **(USDOI 2011a)**. As shown in Table 3–14, Steese NCA encompasses approximately 460,000 hectares (110,000 acres), and approximately 130,000 hectares (309,000 acres) of Steese NCA are located within the PFRR launch corridor.

Recreational activities within Steese NCA during the summer include hiking and backpacking, hunting and wildlife viewing, bird-watching, canoeing and rafting, fishing, and rock climbing. The Pinnell Mountain National Recreation Trail is located within the North Unit of Steese NCA. It is a primitive trail marked with wooden mileposts and rock cairns. The trail has two emergency trail shelters and is closed to all motorized vehicles **(USDOI 2011d)**. Part of Birch Creek Wild and Scenic River is located within Steese NCA. River float trips offer visitors opportunities to view scenery and experience remoteness.

Most recreational activities within Steese NCA are conducted during the summer; however, many winter activities, including snowmobiling, dog mushing, trapping, and cross-country skiing, are popular in March and April. Sled dog racers in the Yukon Quest International Sled

Dog Race traverse the western corner of the South Unit of Steese NCA each February **(USDOI 2011e)**.

Steese NCA receives an estimated 10,000 visits per year. The largest number of users arrives during the caribou and moose hunting season, from August 10 to September 15. A noticeable increase in use has occurred over the past 10 years **(USDOI 2012a)**.

3.8.2.3 *Arctic National Wildlife Refuge*

Encompassing approximately 8 million hectares (20 million acres), Arctic NWR is located in northeastern Alaska and is administered by USFWS as a unit of the National Wildlife Refuge System. On December 6, 1960, Arctic Range was established for the purpose of preserving its unique wildlife, wilderness, and recreational values; in 1980 it was renamed and expanded pursuant to ANILCA **(USFWS 2011c)**. Mollie Beattie Wilderness Area, also established by ANILCA, is located within Arctic NWR, and contains more than 40 percent of the Refuge's land area. It is centered around eastern Brooks Range, an area of Arctic, subarctic, and alpine ecosystems. The Wilderness Act of 1964 **(16 U.S.C. 1131–1136)**, Section 2(a), states that wilderness areas are to be administered for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness. Further, Section 4(c) of the Wilderness Act restricts the use of temporary roads, motor vehicles, and motorized equipment or motorboats; landing of aircraft; other forms of mechanical transport; and structures and installations within a wilderness area. Arctic NWR manages the Mollie Beattie Wilderness Area to preserve the area's natural, scenic condition and the wild character of its creatures and natural processes **(USFWS 2011c)**.

Approximately 4.9 million hectares (12 million acres) of Arctic NWR (including 1.6 million hectares [4.0 million acres] of Mollie Beattie Wilderness Area) are located within the PFRR launch corridor. Two areas of Arctic NWR have been designated Research Natural Areas (RNAs) and are managed to preserve examples of major ecosystem types, to provide opportunities for research and education, and to preserve a full range of genetic and behavioral diversity in native plants and animals. These RNAs include the Firth River-Mancha Creek RNA and the Shublik Springs RNA. Both RNAs are located within Mollie Beattie Wilderness Area **(USFWS 2011c)**.

Recreational activities within Arctic NWR include river floating, hiking, backpacking, camping, long-distance expeditions, mountaineering, dog sledding, berry picking, wildlife viewing, hunting, fishing, and photography. Hunting is a popular activity at Arctic NWR, and most recreational hunters visit to hunt Dall sheep, caribou, moose, and/or brown bears. Hunters usually hike, camp, and float rivers while hunting. River floating is the most frequently reported activity for commercially supported visitors to Arctic NWR. Most people visit Arctic NWR during the summer and fall seasons in June, July, August, and September. This recreational season is short due to weather and river conditions, with a total of 6 to 8 weeks when water levels in most rivers are adequate for floating and the weather is ideal for backpacking. The primary means of access for all visitors in and out of Arctic NWR is by aircraft **(USFWS 2011c)**. Mollie Beattie Wilderness Area is managed to provide challenging recreational activities like hiking, backpacking, climbing, kayaking, canoeing, rafting, horse packing, bird watching, stargazing, and extraordinary opportunities for solitude. Unless specified, no motorized equipment or mechanical transport, except wheelchairs, is allowed within Mollie Beattie Wilderness Area **(Wilderness.net 2011)**. In 2010, an estimated 720 people visited Mollie Beattie Wilderness Area **(USFWS 2011c)**.

Visitors may come and go from Arctic NWR without campsite assignments or registration requirements. Arctic NWR has no formal registration system to comprehensively track visitor use and recreation trends, and managers currently use no formal methods to document visitors who access the refuge on their own without the commercial services of a guide or commercial air operator. An unknown number of visitors enter Arctic NWR each year by private planes and boats or by hiking. In 2009, estimated that the total number of documented visitors was approximately 1,000 people. The number of visitors who do not use commercial services to access the Arctic NWR is most likely higher than what is reflected by the voluntary reports collected at these locations **(USFWS 2011c)**.

3.8.2.4 *Yukon Flats National Wildlife Refuge*

Yukon Flats NWR is situated in the northeastern part of the interior of Alaska south of Brooks Range and north of the Crazy and White Mountains of the Alaska Range. Yukon Flats NWR is administered by USFWS as a unit of the National Wildlife Refuge System and was established in 1980 under ANILCA to conserve fish and wildlife populations and habitats in their natural diversity, including nesting waterfowl, other migratory birds, Dall sheep, bears, moose, wolves, wolverines, other furbearers, caribou, and salmon; to fulfill international treaty obligations; to provide for continued subsistence uses; and to ensure necessary water quality and quantity **(USFWS 2011d)**. Yukon Flats NWR encompasses most of the area known as the Yukon Flats and extends 350 kilometers (220 miles) east-west along the Arctic Circle from the Dalton Highway and Trans-Alaska Pipeline System in the west to within 48 kilometers (30 miles) of the Canadian border in the east, and about 190 kilometers (120 miles) north-south. The Yukon River flows through the middle of Yukon Flats NWR and is the dominant physical feature within Yukon Flats NWR **(USFWS 2008b)**. Within the exterior boundaries are approximately 1.0 million hectares (2.5 million acres) of land selected by, or conveyed to, Native Corporations and Native allotment holders. Five villages—Beaver, Birch Creek, Chalkyitsik, Fort Yukon, and Stevens Village—are within the Yukon Flats NWR boundary. As shown in Table 3–14, Yukon Flats NWR encompasses approximately 4.5 million hectares (11 million acres), and approximately 3.3 million hectares (8.2 million acres) of Yukon Flats NWR are located within the PFRR launch corridor.

Recreational activities within Yukon Flats NWR include fishing, hunting and trapping, photography, camping, hiking, wildlife viewing, and scenic flights. Yukon Flats NWR is open to hunting and is subject to Alaska state regulations (subsistence hunting is addressed in Section 3.10). Most of the fishing that occurs within Yukon Flats NWR also includes non-recreational subsistence activities. Forty permitted cabins, situated along rivers and streams, are located within Yukon Flats NWR. These cabins are permitted for trapping-related activities only. Trappers access these cabins by snowmobile or ski plane **(USFWS 2008b)**.

River boating, for both recreation and transportation of goods and people, is one of the main modes of transportation within Yukon Flats NWR during the summer and fall. Most of the recreational use on the Yukon Flats NWR involves float trips, often combined with hunting expeditions **(USFWS 2008b)**.

In 1980, USFWS estimated that recreational use of Yukon Flats NWR totaled fewer than 1,000 visitor days per year. Yukon Flats NWR staff estimated 500 visitor days of recreation use in Yukon Flats NWR in 2003. Recreational visitation in 2004 and 2005 was believed to be lower than in 2003 due to the large number of wildfires in the area **(USFWS 2010a)**. Recreational visits on Yukon Flats NWR are difficult to quantify because of its size and remoteness, and because only users with permits from Yukon Flats NWR are required to report their use of Yukon Flats NWR lands and waters. Therefore, only users brought onto Yukon Flats NWR by air taxi or on a guided excursion are reported. Most of the visitation to Yukon Flats NWR reported in 2003 was in the vicinity of Beaver Creek **(USFWS 2010a)**.

3.8.2.5 *Alaska State Lands*

The Upper Chatanika River State Recreation Site, an ADNR state park unit, is located in the PFRR launch corridor. This recreation area is located on the banks of the Chatanika River. ADNR manages this area to develop, conserve, and enhance natural resources for present and future Alaskans. The Upper Chatanika State Recreation Area consists of 30 hectares (73 acres), and activities within the recreation area include camping, boating, and fishing **(ADNR 2011)**. No visitor estimates were found for the Upper Chatanika River State Recreation Site.

The ADNR Poker Flat North and South Special Use Areas (ADL 412457 and ADL 414364) are located within the ROI **(ADNR 1990a, 1990b)**. These special use areas include over 20,000 hectares (49,000 acres) of land north and east of the PFRR launch site **(NASA 2000a)**. These areas are described as lands where rocket and rocket booster impacts as a result of research conducted at PFRR are allowed without further authorization **(ADNR 1990a, 1990b)**.

3.8.2.6 *Alaska Native Land Holdings*

Arctic Slope Regional Corporation (ASRC) was established pursuant to the Alaska Native Claims Settlement Act (ANCSA). ASRC is owned by Inupiat Eskimo shareholders, who primarily live in eight villages on Alaska’s North Slope, above the Arctic Circle. ASRC owns title to nearly 2 million hectares (5 million acres) of land on Alaska’s North Slope that contain a high potential for oil, gas, coal, and base metal sulfides. Additionally, ASRC owns subsurface rights to certain lands and surface rights to other lands. As a steward of the land, ASRC continuously strives to balance management of cultural resources with management of natural resources **(ASRC 2011)**.

Doyon, Limited, is the largest private landowner in Alaska and one of the largest private landowners in North America. Doyon owns and manages nearly 4 million hectares (10 million acres), primarily around the 34 villages in the Fairbanks region. Management of Doyon lands focuses on protection of traditional shareholder uses and responsible economic development of natural resources **(Doyon Limited 2011)**.

Venetie is located on the north side of the Chandalar River approximately 72 kilometers (45 miles) northwest of Fort Yukon. In 1971, Venetie and Arctic Village obtained the title to

730,000 hectares (1.8 million acres) of land, which they own as tenants in common through the Native Village of Venetie Tribal Government. Subsistence activities are an important part of the local culture **(ADCRA 2011)**. Subsistence uses are discussed further in Section 3.10.

The villages of Beaver, Birch Creek, Chalkyitsik, Fort Yukon, Kaktovik, and Stevens Village are located within the PFRR launch corridor. Native villages within the ROI are discussed in detail in Section 3.9.3.4.

3.9 CULTURAL RESOURCES

Cultural resources are any prehistoric or historic district, site, building, structure, or object considered important to a culture or community for scientific, traditional, religious, or other purposes. They include archaeological resources, historic architectural resources, and traditional resources. Archaeological resources are locations where prehistoric or historic activity measurably altered the earth or produced deposits of physical remains (*e.g.*, arrowheads, bottles). Historic architectural resources include standing buildings and other structures of historic or aesthetic significance. Architectural resources generally must be more than 50 years old to be considered for inclusion in the National Register of Historic Places (NRHP), although resources dating to defined periods of historical significance, such as the Cold War era (1945–1989), may also be considered eligible. Traditional cultural resources are associated with cultural practices and beliefs of a living community that are rooted in its history and are important in maintaining the continuing cultural identity of the community. Properties of traditional or religious cultural importance may be determined to be eligible for inclusion in NRHP **(16 U.S.C. 470 *et seq.*)**.

Historic properties (as defined in **36 CFR 60.4**) are significant archaeological, architectural, or traditional cultural properties that are either listed in, or eligible for listing in, NRHP. Historic properties, including traditional cultural properties and other significant traditional resources identified by Alaska Natives, are evaluated for potential adverse impacts from an action.

The ROI for cultural resources is defined as the PFRR launch site and launch corridor. As required by the implementing regulation of Section 106 of the National Historic Preservation Act (NHPA), NASA is currently consulting with the Alaska State Historic Preservation Office (SHPO).

3.9.1 Regulatory Setting

The foundation for general legislation for preservation of cultural resources is NHPA **(16 U.S.C. 470 *et seq.*)**. Two sections of NHPA, Sections 106 and 110, outline the processes Federal agencies must follow to manage and protect cultural resources or historic properties. Under NHPA and its implementing regulations, only significant cultural resources are considered when assessing the possible impacts of a Federal undertaking or action. Significant archaeological, architectural, and traditional cultural resources are those that are listed or eligible for listing in NRHP. Section 106 requires Federal agencies to consider the effects of actions on historic properties through a consultation process. Processes outlined in Section 106 include resource identification/inventory, evaluation of significance, assessment of adverse effects on significant historic properties, and resolution of adverse effects.

Cultural resources are protected under a number of other laws, including the Antiquities Act of 1906 **(16 U.S.C. 431–433)**, the Historic Sites Act of 1935 **(16 U.S.C. 461–467)**, the American Indian Religious Freedom Act of 1978 **(42 U.S.C. 1996)**, the Archaeological Resources Protection Act of 1979 **(16 U.S.C. 470aa–470mm)**, and the Native American Graves Protection and Repatriation Act of 1990 **(25 U.S.C. 3001 *et seq.*)**. In addition, Executive Order 13287, *Preserve America*, signed March 3, 2003, directs Federal agencies to increase their knowledge of historic resources in their care and to enhance the management of these assets and promote intergovernmental cooperation and partnerships for the preservation and use of historic properties.

Several Presidential Memoranda and Executive Orders address the requirement of Federal agencies to notify or consult with American Indian tribes or otherwise consider their interests when planning and implementing Federal undertakings. In particular, on April 29, 1994, President William J. Clinton issued the *Memorandum on Government-to-Government Relations with Native American Tribal Governments*, which specifies a commitment to developing more effective day-to-day working relationships with sovereign tribal governments. This has been reinforced by subsequent administrations through additional memoranda (President George W. Bush, 2004, *Government-to-Government Relationship with Tribal Governments*, and President Barack H. Obama, 2009, *Tribal Consultation*). In addition to the memoranda, Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments* (November 6, 2000), reaffirms the U.S. Government's responsibility for continued collaboration and consultation with tribal governments in the development of Federal policies that have tribal implications, to strengthen the government-to-government relationships with American Indian tribes, and reduce the imposition of unfunded mandates upon American Indian tribes. Executive Order 13007, *Indian Sacred Sites*, issued May 24, 1996, requires that in managing Federal lands, agencies must accommodate access to, and ceremonial use of, sacred sites, which may or may not be protected by other laws or regulations, and must avoid adversely affecting the physical integrity of these sites.

The Alaska Office of History and Archaeology implements the Alaska Historic Preservation Act **(Alaska Statute 41.35.70)** and works to preserve sites and buildings that reflect the heritage of Alaska. NASA also has several policy documents that address or include cultural resources.

3.9.2 Historic Background

Discussion of the cultural landscape of Alaska is commonly divided into two general periods: prehistory and history. **Table 3–15** broadly outlines the dates and characteristics of the prehistoric and historic periods of Alaska.

Prehistory refers to the period for which no documentary (*e.g.*, written) evidence exists of the events or people living during that time. Alaskan prehistory varies regionally due to natural conditions that either enhanced or limited human occupation in a given area of the state. The extent of glacial coverage and the rate and direction of glacial retreat greatly influenced the capacity of a region to support prolonged human occupancy and activity. Evidence suggests that interior portions of Alaska were inhabited at least 13,000 years ago, and coastal regions were inhabited later.

Table 3–15. Summary of History and Prehistory Periods of Interior and Northeastern Alaska

Era	Dates	Description
Prehistoric Era		
Paleoindian	14,000–10,000 BP	Small, mobile bands of big game hunters camped at sites with views of the plains. Artifacts include fluted projectile points.
Paleoarctic Tradition	12,000–8,000 BP	Early inhabitants camped on terraces and bluffs above treeless steppes, hunted large mammals such as bison and mammoth. Artifacts include tools fashioned from stone, bone, antler, and ivory; microblades; and microblade cores.
Northern Archaic Tradition	8,000–3,000 BP	Adaptations due to boreal forest expansion, such as side-notched projectile points. Tools include bifacial knives, microblades, end scrapers, and side-notched points. Possibly ancestral to modern Athapaskans of the region.
Arctic Small Tool Tradition	5,000–2,400 BP	Broad-based economy relied on maritime, land, and riverine resources. Tools include small, well-made, flaked stone microblades; burins; and other tools of chert and obsidian. Possibly ancestral to modern Inupiat Eskimos of the region.
Athapaskan Tradition	2,500–European contact	Varied settlement patterns, often nomadic culture, subsisting primarily on terrestrial animals; subgroups exhibit distinct cultural characteristics. Modern villages have descendants of historic residents.
Inupiat Tradition (Birnirk and Thule cultures)	2,000–European contact	Increased reliance on marine resources, but continuity in material, tool traditions similar to Arctic Small Tool Tradition suggests direct descent from Thule culture. Semi-subterranean winter houses; seasonal hunting of seal, walrus, caribou, occasionally whales. Kaktovik residents are descendants of Thule culture.
Historic Era		
Early Contact	1820s–1850s	Contact between Alaska Native groups and Russian or English whalers, often at trading posts; introduction of trade goods and disease.
Gold Rush	1860s–1920s	Period of influx of Euroamerican settlement in interior Alaska in response to multiple gold discoveries.
Development of Infrastructure	1890s–1940s	Establishment of roads and railway connecting interior Alaska with other areas; advances in air travel open interior and far north to more contact and commerce.
World War II and post-World War II development	1939–Present	World War II and Cold War led to military increases. Increased military presence in interior, beginning with the establishment of Ladd Field, Fairbanks. Statehood in 1959 and discovery of oil led eventually to enactment of ANCSA and ANILCA. Poker Flat Research Range established by the University of Alaska–Fairbanks in 1968.

Key: ANCSA=Alaska Native Claims Settlement Act; ANILCA=Alaska National Interest Lands Conservation Act; BP=Before the Present.

Source: Alaska Humanities Forum 2011; NPS 2011; USFWS 2011c.

Alaska's earliest inhabitants were nomadic hunters who traveled in small bands. This social organization persisted through the arrival of European traders in the late 1810s, and their habitation in the region continues to the present day. The nomadic nature of the state's earliest inhabitants, coupled with the organic nature of the materials they manufactured and used and changing environmental conditions, has presented difficulties in finding evidence of their activities. Archaeological evidence is usually limited to lithic (stone) artifacts, such as projectile points, cutting tools, scrapers and waste flakes, and hearths.

Historic refers to the period following the introduction of written records. The transition from the prehistoric to the historic period in Alaska varies from region to region. Western trade goods and diseases began to enter the interior of Alaska prior to actual contact, and definitely by the early 1800s. For interior Alaska, the historic period begins with the migration of Russian fur traders around the 1830s. The early historic period is marked by the continuation of traditional activities, with the addition of a limited European presence in the region. Gold rushes began in the late 1880s and substantially altered the regional demographics and economy.

Native people still compose a large part of the population of Arctic Alaska, as well as the population of interior Alaska. Inuit Eskimos occupy the Arctic coastal region, while Athapaskans occupy the interior. The Athapaskans of the ROI are primarily Gwich'in Athapaskans. Native indigenous occupation dates back more than 10,000 years, to the end of the last ice age, and possibly as far back as 20,000 years. Coastal Inuit culture is, in large part, a sea mammal hunting culture, with land animals also playing a part in subsistence. Athapaskan culture is based largely on harvesting caribou, moose, and salmon.

World War II and the Cold War drew thousands of people to Alaska for military service and deployment. Military installations were constructed throughout Alaska during and in the years directly following World War II. Since the statehood of Alaska in 1959, the Trans-Alaska Pipeline, Alaska Native land claim settlements, and public lands legislation have each had profound influences on the region.

PFRR was established by the Geophysical Institute of UAF in 1968. NASA and the Geophysical Institute established a cooperative operating agreement in 1979. The area near PFRR saw the largest gold dredging operation conducted by the Fairbanks Exploration Company (F.E. Co.) from the late 1920s to the late 1950s **(Sattler *et al.* 1993)**. The remnants of the F.E. Co. dredging operations and patented ground lie adjacent to the southern property boundary of the PFRR launch site. Private lands next to PFRR include the NRHP-eligible former Chatanika Camp (Alaska Heritage Resources Survey No. LIV-023) and Seppala Cabin (LIV-117). Other historic properties within 2 or 3 miles of the PFRR launch site include the remnants of the mining boom town Old Chatanika (LIV-087), and the former town site of Cleary (LIV-021) **(Sattler *et al.* 1993)**.

3.9.3 Existing Conditions

Cultural resources in the PFRR launch corridor include prehistoric archaeological sites; historic archaeological sites and properties; and properties of traditional, religious, and cultural importance that reflect the history described in Section 3.9.2. Prehistoric sites are often found in locations that are higher in elevation than the surrounding landscape, such as bluffs and terraces, and usually in proximity to water, including rivers, drainages, and lake margins. Historic sites in the region are often associated with historic roads or trails, rivers, drainages, and lake margins. Cold War era historic properties are found on military installations and scattered in villages in this region. Properties of traditional religious and cultural importance are found throughout the region and are identified through consultation with tribes that have knowledge of the geographical area of interest.

3.9.3.1 *National Register of Historic Places*

There are no NRHP-listed properties within the PFRR launch site. One NRHP-listed resource lies beneath the PFRR launch corridor. The Mission Church, built in 1916 or 1917 by residents of Arctic Village, was listed in NRHP in 1976 (NPS Reference No. 77001578) **(NRHP 2011)**. No other listed properties are present directly beneath the PFRR launch corridor, and there are no National Historic Landmarks. The Old Mission House (NPS Reference No. 78000539, listed in 1978) and Sourdough Inn (NPS Reference No. 97001585, listed in 1997) lie between Flight Zones 4 and 5, in Fort Yukon **(NRHP 2011)**. The Chatanika Gold Camp (NPS Reference No. 79003753) is located adjacent to Steese Highway just south of the PFRR entrance road and outside the PFRR launch site **(NRHP 2011)**.

3.9.3.2 *Archaeological Sites*

Two historic trails were documented within the PFRR launch site. The trails date at least to 1907 and are considered to be eligible for listing in NRHP **(Sattler *et al.* 1993)**.

There are many prehistoric and historic native sites and historic properties within the PFRR launch corridor. Most have not been evaluated for NRHP eligibility. However, it is likely that many of these resources are eligible for listing in NRHP, and thus are treated as such until such time as they might be formally evaluated. Alaska Native archaeological resource types include remains of habitations, sometimes with stone tent rings; driftwood or whalebone house frames; cemeteries; caribou drive lines or fences and corrals; and camps (sometimes characterized by lithic scatters or housepits).

There are also many historic era archaeological sites in the PFRR launch corridor, including artifacts from the U.S. military (World War II and Cold War), gold mining, mineral and oil exploration, homesteading, transportation and aviation, cemeteries, and architecture.

3.9.3.3 *Structural Resources*

Remnants of the early mining days are evident near the PFRR launch site. Three manmade diversions are part of the NRHP-eligible Davidson Ditch. Davidson Ditch runs for over 110 kilometers (70 miles) and was created to bring sluicing water to the mines on lower Cleary Creek and Chatanika Flats. The middle Davidson Ditch was constructed in 1909. The upper Davidson Ditch was constructed in 1925. The ditches at the PFRR launch site are now overgrown with vegetation and breached at various points along their length. The lower ditch is nearly completely obliterated. Despite this deterioration, these structures are eligible for listing in NRHP **(Sattler *et al.* 1993)**.

Several historic structures were documented during the 1993 survey **(Sattler *et al.* 1993)**. A compound that includes a former telemetry station was determined not eligible for listing in NRHP. A telegraph line may be eligible for NRHP. A small mining drift and telephone pole, as well as three prospects, were not assigned state numbers and are not eligible.

Structural remains beneath the PFRR launch corridor include numerous cabins, some of which may be eligible for listing in NRHP.

3.9.3.4 *Native Villages*

The cultural makeup of Arctic Alaska is Inupiat Eskimo, in large part a sea mammal hunting culture. Interior villages are home to people of Athapaskan descent: Gwich'in, Koyukon, and Tanana Athapaskan Indian. Their culture is based largely on harvesting caribou, moose, and salmon. Most of the communities beneath or near the PFRR launch corridor are occupied by Alaska Natives, and many are the seat of federally recognized tribes (see Figure 3–1). Native villages that are in close in proximity to the PFRR launch corridor own land, along with Doyon, Limited, in Yukon Flats NWR. About 1 million hectares (2.5 million acres) of land in Yukon Flats NWR are under native ownership **(USFWS 2011c)**. Kaktovik, in the far north and within Arctic NWR, is part of the Arctic Slope Corporation. The Village of Venetie owns land as a reservation, rather than as part of one of the Alaska Native corporations. Federally recognized Alaska Native groups under or near the PFRR launch corridor include those listed in **Table 3–16**. Native life in most of these villages retains a strong reliance on subsistence activities. Winter subsistence activities for these communities include hunting, trapping and fishing. See Section 3.10 for information regarding subsistence uses.

Table 3–16. Villages Beneath or Near the Poker Flat Research Range Launch Corridor

Village	Federally Recognized Tribe or Other	Federal Management Area
Beneath Poker Flat Research Range Launch Corridor		
Arctic Village	Native Village of Venetie Tribal Government; Neets'aii Gwich'in of Arctic Village	At the southern boundary of Arctic National Wildlife Refuge
Beaver	Beaver Village. Predominantly mixed Gwich'in/Koyukuk Athapaskan and Inupiat Eskimo.	Yukon Flats National Wildlife Refuge
Chalkyitsik	Chalkyitsik Village. Traditional Gwich'in Athapaskan village	Yukon Flats National Wildlife Refuge
Kaktovik	Kaktovik Village (also known as Barter Island). Inupiat Eskimo traditions.	At the northern boundary of the Arctic National Wildlife Refuge in the North Slope Borough on the Arctic (or Beaufort) coast

Table 3–16. Villages Beneath or Near the Poker Flat Research Range Launch Corridor (*continued*)

Village	Federally Recognized Tribe or Other	Federal Management Area
Beneath Poker Flat Research Range Launch Corridor (*continued*)		
Venetie	Village of Venetie; Native Village of Venetie Tribal Government (Arctic Village and Village of Venetie. Largely descendants of Neets'ai Gwich'in and to lesser extent, Gwichyaa and Dihaii Gwich'in. Village council combined with Arctic Village.	At northern border of Yukon Flats National Wildlife Refuge
Between Launch Corridors		
Birch Creek	Birch Creek Tribe; Dendu Gwich'in Tribal Council; local residents are Dendu Gwich'in Athapaskans.	Yukon Flats National Wildlife Refuge
Fort Yukon	Native Village of Fort Yukon; Canyon Village Traditional Council (not federally recognized). Most descendents of Yukon Flats, Chandalar River, Birch Creek, Black River, and Porcupine River Gwich'in Athapaskan tribes.	Yukon Flats National Wildlife Refuge
Outside Poker Flat Research Range Launch Corridors		
Central	None	East of launch corridor
Chatanika	None	At base/apex of launch corridor
Chena Hot Springs	None	South of launch corridor
Circle	Circle Native Community. Predominantly Athapaskan.	East of launch corridor and east of Yukon Flats National Wildlife Refuge
Circle Hot Springs	None	East of launch corridor
Eureka	None	West of launch corridor, Dalton Highway
Livengood	None	West of launch corridor
Miller House	None	East of launch corridor
Olnes	None	Southwest of Chatanika
Rampart	Rampart Village. Predominantly Koyukon Athapaskan.	West of launch corridor, Dalton Highway
Stevens Village	Native Village of Stevens. Predominantly Kutchin (Gwich'in) Natives.	West of the launch corridor and in Yukon Flats National Wildlife Refuge
Wiseman	None	West of launch corridor

Arctic Village

Arctic Village lies at the north end of the PFRR launch corridor Flight Zone 4, at the southern boundary of Arctic NWR, on the east fork of the Chandalar River. Archaeological evidence indicates the location of Arctic Village may have been first occupied as long ago as 6,500 years before present. The semi-nomadic life of the Neets'aii Gwich'in included seasonal rounds that took them to the Arctic Coast, Rampart, Old Crow, the Coleen River, and Fort Yukon. Some semi-permanent camps were also established in locations such as Arctic Village, Christian, Venetie, and Sheenjak. The Neets'aii Gwich'in traded with the Inupiat Eskimos on the Arctic coast, and also provided caribou meat to Fort Yukon **(ADCRA 2011)**. As one of the communities of the former Venetie Indian Reservation (established in 1943), a branch of the federally recognized Native Village of Venetie tribal government is located in Arctic Village. The Neets'aii Gwich'in of Arctic Village continue to lead a subsistence-based lifestyle, hunting caribou, moose, sheep, porcupine, rabbit, ptarmigan, freshwater fish, and waterfowl and harvesting berries **(ADCRA 2011)**.

Beaver

At the southern end of the PFRR launch corridor Flight Zone 3, Beaver sits on the north bank of the Yukon River. Although originally established in 1907 as a trading post and jumping-off point for the gold fields to the north, Beaver is also home to a federally recognized tribe. The Beaver Village members are a mix of Gwich'in/Koyukuk Athapaskan and Inupiat Eskimo. Subsistence forms an important part of their lifestyle, with activities including hunting moose, salmon, freshwater fish, bear, and waterfowl. Gardening and berry harvesting are also important activities **(ADCRA 2011)**.

Chalkyitsik

The Alaska Native Village Chalkyitsik underlies the PFRR launch corridor Flight Zone 5 on the Black River. Archaeological excavations indicate this region may have been first used as early as 12,000 years ago. This village on the Black River has traditionally been an important seasonal fishing site for the Gwich'in. Village elders remember a highly nomadic way of life where, from autumn into the spring, they lived at the headwaters of the Black River, and fished downriver in the summer. Contact with early explorers was limited, and the Black River Gwich'in receives scant mention in early records. The location of the village at its present site is due in part to low water in the Black River in the 1930s. A boat carrying materials intended for a school to be built in Salmon Village had to be unloaded at the Chalkyitsik seasonal fishing camp that then consisted of four cabins. Rather than reload the construction materials, the school was built at Chalkyitsik, and the Black River people began to settle around the school. The federally recognized Chalkyitsik Village is composed of Gwich'in Athapaskans who live a subsistence lifestyle, hunting primarily moose, caribou, sheep, salmon, and whitefish.

Kaktovik

The community of Kaktovik lies on the Beaufort Sea of the Arctic Ocean, on Barter Island, at the northern extent of the PFRR launch corridor Flight Zone 4AX. Although the city was not incorporated until 1971, Barter Island has long been a trading center for commerce between the

Inupiat of Alaska and the Inuit of Canada. The federally recognized tribe of Kaktovik Village is located in Kaktovik, made up primarily of Inupiat Eskimo who lives a traditional, subsistence-based life, centered on caribou **(ADCRA 2011)**.

Venetie

This community lies on the north side of the Chandalar River on the boundary between the PFRR launch corridor Flight Zones 3 and 4, at the northern boundary of Yukon Flats NWR. The federally recognized Village of Venetie is also part of the Native Village of Venetie Tribal Government that includes Arctic Village. The village was founded in 1895, the central location for a small grouping of cabins. The people living there were seasonally nomadic, following food sources. A gold rush in 1906 brought miners to the Chandalar gold region, but the boom did not last, as the gold was mostly played out by 1910. The residents of Venetie joined with those of Arctic Village, Christian Village, and Robert's Fish Camp to establish the Venetie Indian Reservation in 1943. When ANCSA provided a corporate organization for Alaska Natives, the members of the Venetie Indian Reservation opted to maintain title to their reservation lands, rather than join the corporation. Subsistence activities, including hunting of salmon, whitefish, moose, caribou, bear, waterfowl, and small game, remain an important part of the lifestyle for the Neets'ai Gwich'in, Gwichyaa, and Dihaii Gwich'in, who are part of the Village of Venetie **(ADCRA 2011)**.

Birch Creek

The community of Birch Creek lies in the gap between the PFRR launch corridor Flight Zones 4 and 5, south-southwest of Fort Yukon. Although there are records of semi-permanent camps in the area, the first documentation of settlement here was in 1862, as a camp that provided fish to the Hudson's Bay Company in Fort Yukon. The Dendu Gwich'in who lived here might have been annihilated by scarlet fever in the 1880s, but the records are inconsistent, and ethnographic accounts document use of the region throughout the latter part of the 19th century. By the 1950s, establishment of a school encouraged families to adopt a less nomadic lifeway. Today, the federally recognized tribe, the Birch Creek Tribe Dendu Gwich'in Tribal Council, represents members who are Dendu Gwich'in, and who also depend heavily on a subsistence economy. They harvest salmon, whitefish, moose, black bear, waterfowl, and berries **(ADCRA 2011)**.

Fort Yukon

Located at the confluence of the Yukon and Porcupine Rivers, Fort Yukon is the largest of the Alaska Native villages in the PFRR region. Like Birch Creek, it lies in the gap between the PFRR launch corridor Flight Zones 4 and 5. The town was established in 1847 as a Canadian outpost in what was then Russian territory. After the United States purchased Alaska, survey showed that Fort Yukon was in the United States. Fort Yukon held an important role as a trading center for this part of Alaska from its founding into the mid 20th century. Despite challenges from flooding and disease in the first half of the century, by the 1950s, Fort Yukon was incorporated and hosted a White Alice Communications System and Air Force station. The federally recognized tribe of the Native Village of Fort Yukon has its home here, as well as the non-recognized Canyon Village Traditional Council. The Council of Athapaskan Tribal Governments also is headquartered in Fort Yukon. Alaska Natives in Fort Yukon are descendants of the Yukon Flats, Chandalar River, Birch Creek, Black River, and Porcupine River Gwich'in Athapaskan tribes **(ADCRA 2011)**. Subsistence plays a major role in the economy, with meat obtained from salmon, whitefish, moose, bear, caribou, and waterfowl **(ADCRA 2011)**.

3.9.3.5 *Properties of Traditional or Religious Cultural Importance*

No specific properties of traditional or religious cultural importance have been defined within the ROI. This is not to say that such localities do not exist. They are typically identified by Alaska Natives through consultation under NHPA Section 106 and government-to-government consultation guidelines. Locations of traditional use may be considered properties of traditional or religious cultural importance, as defined under NHPA **(16 U.S.C. 470a(d)(6))**. Traditional land use inventories in other regions of Alaska have identified hundreds of potentially significant locations. For example, the inventory for the Northeast National Petroleum Reserve to the west of PFRR identified over 220 such locations. It is highly likely that similar resources are located throughout the ROI and might include fishing and hunting areas, cabins, and ruins of other structures, such as sod houses or fences, gravesites, and landmarks. An overlapping list of this resource type may be obtained through the compilation of place names. Over 500 place names were identified for the *Yukon Flats Land Exchange Environmental Impact Statement* **(USFWS 2010a)**, many of which lie under PFRR **(USFWS 2008b)**. NASA is currently in consultation with Alaska Native tribes to identify resources of this type.

3.10 SUBSISTENCE USE RESOURCES

Subsistence plays a vital role in the lifestyles of Alaskan residents, particularly rural residents and Alaska Natives, and is a unique characteristic of life in Alaska. "Subsistence Management Regulations for Public Lands in Alaska" **(36 CFR 242)** defines subsistence as the "customary and traditional uses by rural Alaska residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade." In the rural regions of Alaska, services and products are not always accessible; subsistence fishing and hunting are important to supplement employment and nutrition in these regions. Approximately 50 percent of the food for three-quarters of the Alaska Native families in the state's smaller communities is acquired through subsistence activities. Other important uses of subsistence products are as follows:

- Clothing, including the use of wild furs and hides for ruffs, mitts, parkas, clothes lining, and winter boots.

- Fuel, specifically wood, is a major source of heat for rural homes, which do not have access to centralized utilities. Wood is also used for smoking and preserving fish or meat.

- Fish, seals, and other products are used to feed dog teams, which are used as transportation.

- Construction materials, specifically spruce, birch, hemlock, willow, and cottonwood, are used for house logs, sleds, and fish racks, among other items.

- Hides are often used as sleeping mats, seal skins are used to store food, and wild grasses are made into baskets and mats.

- Specialized products like seal oil are bartered and exchanged in traditional trade networks between communities. Furs are sold to outside markets to provide an important source of income for rural communities. Ivory, grass, wood, skins, and furs are also crafted into items for use and sale in outside markets.

For Alaska Natives, many of the subsistence products are used in traditional ceremonies such as funerals, potlatches, marriages, native dances, and other ceremonial occasions.

Under state regulations, subsistence is open to all Alaska residents on state or private land, but under Federal regulations, subsistence is limited to rural residents on federally owned lands. Due to the disparity between Federal and state subsistence regulations, the jurisdiction for managing subsistence has been divided between the State of Alaska and the Federal Subsistence Board. Under Federal regulations, all communities and areas in Alaska are considered rural, with the exception of major towns and cities and their surrounding areas. Access to subsistence resources using a preference system is tied to the permit system for hunting and takes limits.

In 1978, the State of Alaska passed legislation regulating subsistence and applying subsistence to rural residents. Additional state legislation was passed in 1989, extending subsistence to all residents. In 1980, Congress passed ANILCA, a priority subsistence law for Federal lands in Alaska. State and Federal law defines subsistence as the “customary and traditional uses” of wild resources for food, clothing, fuel, transportation, construction, art, crafts, sharing, and customary trade. Under these laws and related regulations, Alaska residents are given priority in harvesting game and nongame resources for personal use over individuals harvesting game and nongame resources for sport or commercial reasons.

ANILCA obligates Federal agencies to manage their lands to support customary and traditional subsistence activities on Federal land, with preference for rural Alaskans to harvest fish and wildlife on Federal lands, particularly when resources are scarce, as evaluated for each species traditionally harvested for subsistence **(16 U.S.C. 314)**.

The ROI for subsistence use resources includes communities under or within 37 kilometers (20 nautical miles) of the PFFR launch site and launch corridor. The ROI includes these areas because there are communities in the vicinity of the PFRR launch corridor that may travel into the launch corridor to harvest subsistence resources in response to wildlife availability. A distance of 37 kilometers (20 nautical miles) was used as a best estimate for the maximum distance traveled without the use of aircraft to harvest subsistence resources. Detailed characteristics of these communities, including characteristics of the state and Federal subsistence uses, are provided in **Table 3–17**. Locations of the game management units (GMUs) are shown in **Figure 3–8**. The state subsistence information is provided by the ADF&G and presents the information for the most representative year for each community. As discussed previously, state subsistence is open to Alaska residents on state or private land. Regional and village Native Corporation lands are considered private lands and are managed under state subsistence guidelines. ADF&G attempted to survey the maximum number of households in each community to gain an adequate sampling of the community and their subsistence habits. Several of these communities have more up-to-date data; however, the information may not provide the most accurate description of the community's reliance on subsistence. Therefore, only the most representative year is presented in Table 3–17 even though the data may be dated. Regulations regarding the state subsistence priority, amount of harvest, harvest season, and methods used in the harvest are dictated by the Alaska Board of Fisheries and the Alaska Board of Game.

Federal subsistence is open on Federal public land only to Alaska residents living in rural communities. Federal public land includes land owned and managed by BLM, NPS, the U.S. Forest Service (USFS), and USFWS. Regulations regarding Federal subsistence priority, amount of harvest, harvest season, and methods used in harvest are dictated by the Federal Subsistence Board, which includes agency heads of BLM, NPS, USFS, USFWS, and the U.S. Bureau of Indian Affairs. Table 3–17 provides information on the Federal subsistence management areas for hunting and fishing for each community. Information on subsistence harvests on Federal public land near these communities is not available. Other GMUs included in the PFRR launch corridor are GMUs 20F, 25B, and 26B. Within GMU-20F, subsistence harvests are permitted for bison, black and brown bear, caribou, moose, sheep, beaver, coyote, fox, hare, lynx, muskrat, wolf, wolverine, grouse, and ptarmigan. Within GMU-25B subsistence harvests are permitted for black and brown bear, caribou, moose, muskox, beaver, coyote, fox, hare, lynx, muskrat, wolf, wolverine, grouse, and ptarmigan. Within GMU-26B subsistence harvests are permitted for black and brown bear, caribou, moose, muskox, sheep, coyote, fox, hare, lynx, wolf, wolverine, and ptarmigan. The USFWS regularly publishes materials indicating the GMU in which specific subsistence harvests are permitted; the manner of harvest, such as trapping or hunting; and the harvest limits for each GMU. Some of these limitations include restrictions of subsistence activities to residents in particular villages or the harvest of subsistence resources only in specific areas. All subsistence participants are required to have appropriate permits prior to subsistence harvesting.

Within the ROI many subsistence participants rely on fishing for both salmon and non-salmon species, large and small land mammals, and a variety of bird species. Fish is one of the most reliable sources of meat that can be harvested nearly year round either through nets or ice fishing. The Yukon River, the Chandalar River, the Black River, and the Porcupine River are main providers of salmon species **(Caulfield 1983)**. A number of other lakes and creeks within the PFRR launch corridor provide non-salmon species. Subsistence fisheries are discussed further in Section 3.7.2.6. Land mammals such as caribou, moose, and Dall sheep in particular, are used as sources of meat. These species are often hunted by boat or snowmachine as they are usually found in close proximity to rivers. Marine mammals can be harvested for subsistence purposes, but only by Alaska Natives, as permitted in the MMPA. The regulations governing subsistence harvests of marine mammals are co-managed by Alaska Natives, USFWS, and NMFS. In addition to caribou, Dall sheep, other small mammals, migratory birds, and fish, the Kaktovik community is dependent on the subsistence hunting of marine mammals, including bowhead whale, bearded seal, ringed seal, and occasionally polar bears **(Bacon *et al.* 2009)**.

Table 3–17. Subsistence Activities in the Vicinity of the PFRR Launch Corridor

			State Subsistence			Federal Subsistence
Village	**2010 Population**	**Percentage Alaska Native**	**Year**	**Species**	**Estimated Harvest (kilograms)**	**Hunting and Fishing Subsistence Areas**
Arctic Village	150	95	1997	Fish (non-salmon species)	880	Yukon-Northern Area Subsistence Fishing
				Large land mammals (bear, caribou, moose, Dall sheep)	3900	GMU-25A, Fort Yukon
				Small land mammals (beaver)	4	
				Birds and eggs, including migratory birds	250	
Beaver	83	98	1996	Fish (salmon and non-salmon species)	950	Yukon-Northern Area Subsistence Fishing
				Large land mammals (black bear, moose)	1,800	GMU-25D, Fort Yukon
				Small land mammals (beaver, hare, snowshoe hare)	80	
				Birds and eggs, including migratory birds	54	
Birch Creek	33	100	1997	Fish (non-salmon species)	170	Yukon-Northern Area Subsistence Fishing
				Large land mammals (black bear, moose)	8,700	GMU-25D, Fort Yukon
				Small land mammals (beaver, hare, snowshoe hare, lynx, squirrel)	500	
				Birds and eggs, including migratory birds	660	

Table 3–17. Subsistence Activities in the Vicinity of the PFRR Launch Corridor (*continued*)

Village	2010 Population	Percentage Alaska Native	State Subsistence			Federal Subsistence
			Year	Species	Estimated Harvest (kilograms)	Hunting and Fishing Subsistence Areas
Central-Circle Hot Springs	96	6.3	2005[a]	Fish (non-salmon species)	620	Yukon-Northern Area Subsistence Fishing
						GMU-25C, Fort Yukon
Chalkyitsik	69	86	1997	Fish (non-salmon species)	330	Yukon-Northern Area Subsistence Fishing
				Large land mammals (black bear, moose)	3,000	GMU-25D, Fort Yukon
				Small land mammals (hare, snowshoe hare, lynx)	103	
				Birds and eggs, including migratory birds	84	
Circle	104	85	1997	Fish (salmon and non-salmon species)	2,900	Yukon-Northern Area Subsistence Fishing
				Large land mammals (black bear, caribou, moose)	2,300	GMU-25D, Fort Yukon
				Small land mammals (beaver, hare, snowshoe hare, lynx)	230	
				Birds and eggs, including migratory birds	480	
Coldfoot	10	10	N/A	N/A	N/A	Yukon-Northern Area Subsistence Fishing
						GMU-24B, Koyukuk

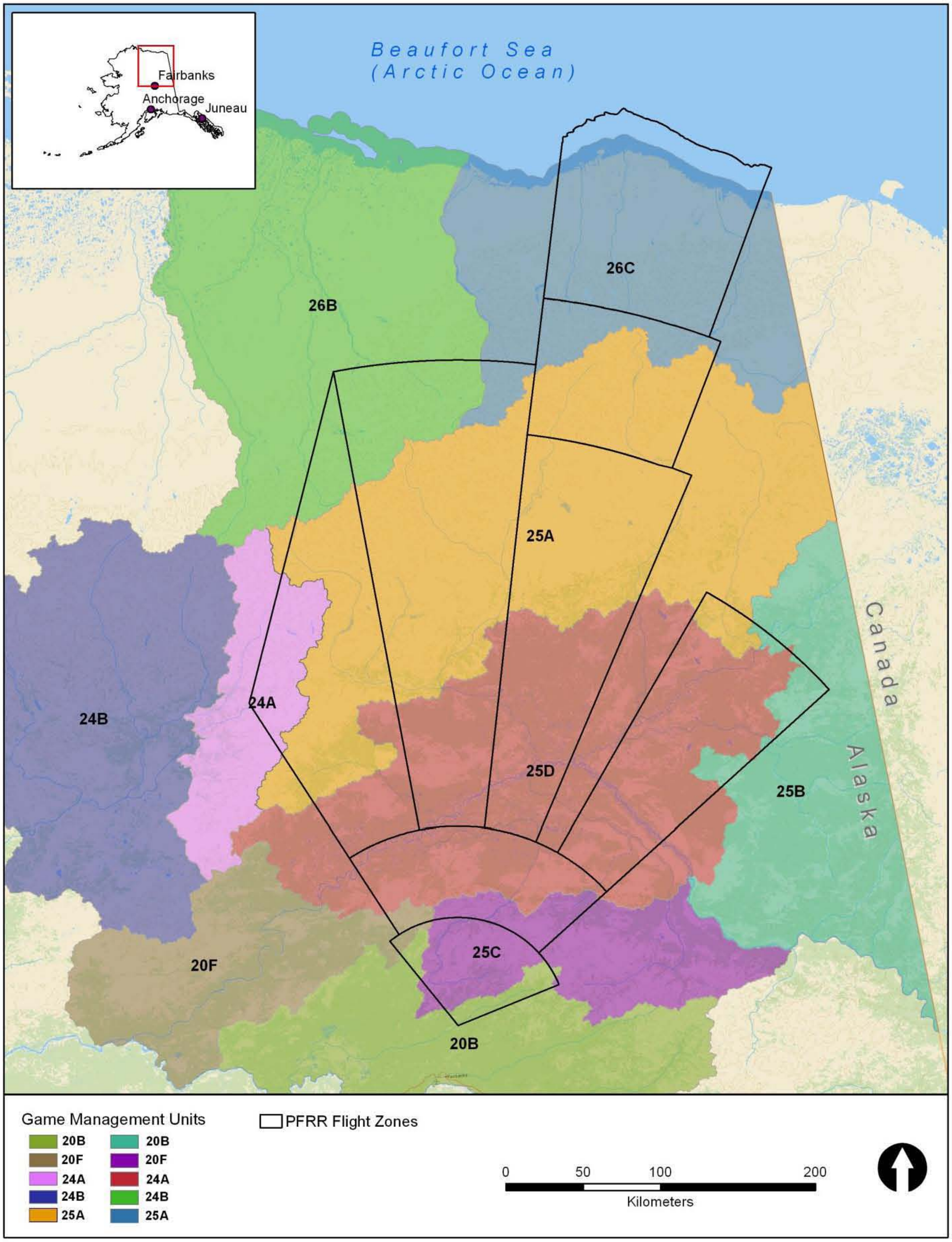
Table 3–17. Subsistence Activities in the Vicinity of the PFRR Launch Corridor (*continued*)

Village	2010 Population	Percentage Alaska Native	State Subsistence			Federal Subsistence
			Year	Species	Estimated Harvest (kilograms)	Hunting and Fishing Subsistence Areas
Fort Yukon	580	90	1997	Fish (salmon and non-salmon species)	26,000	Yukon-Northern Area Subsistence Fishing
				Large land mammals (black bear, caribou, moose)	11,000	GMU-25D, Fort Yukon
				Small land mammals (beaver, hare, snowshoe hare, lynx, squirrel)	770	
				Birds and eggs, including migratory birds	1,400	
Kaktovik	240	90	1992	Fish (salmon and non-salmon species)	10,000	Yukon-Northern Area Subsistence Fishing
				Large land mammals (brown bear, caribou, moose, muskox, Dall sheep)	13,000	GMU-26C, Arctic Slope
				Small land mammals (marmot, squirrel)	73	
				Marine mammals (polar bear, seal species, walrus, bowhead whale)	52,000	
				Birds and eggs, including migratory birds	1,500	
Livengood	13	31	N/A	N/A	N/A	Yukon-Northern Area Subsistence Fishing
						GMU-20B, Fairbanks-Central Tanana

Table 3–17. Subsistence Activities in the Vicinity of the PFRR Launch Corridor (*continued*)

Village	2010 Population	Percentage Alaska Native	State Subsistence			Federal Subsistence
			Year	Species	Estimated Harvest (kilograms)	Hunting and Fishing Subsistence Areas
Stevens Village	78	90	1994	Fish (salmon and non-salmon species)	2,100	Yukon-Northern Area Subsistence Fishing
				Large land mammals (moose)	1,700	GMU-25D, Fort Yukon
				Small land mammals (snowshoe hare)	210	
				Birds and eggs, including migratory birds	47	
Venetie	170	96	1997	Fish (salmon species)	120	Yukon-Northern Area Subsistence Fishing
				Large land mammals (moose)	4,800	GMU-25D, Fort Yukon
				Small land mammals (beaver, snowshoe hare, squirrel)	140	
				Birds and eggs, including migratory birds	45	
Wiseman	14	7.1	N/A	N/A	N/A	Yukon-Northern Area Subsistence Fishing
						GMU-24B, Koyukuk

a. Only year of data available.
Note: To convert kilograms to pounds, multiply by 2.2046.
Key: GMU=Game Management Unit; N/A=not applicable.
Source: ADF&G 2011c; Census 2011; USFWS 2010a, 2011o.



Note: To convert kilometers to miles, multiply by 0.6214.
Source: SAIC 2011.

Figure 3–8. Poker Flat Research Range Game Management Units Ecoregions

In general, subsistence activities occur year-round. Harvesting vegetation such as berries or other roots or vegetables typically occurs in late summer as the vegetation ripens. Subsistence hunting and trapping are regulated by the hunting and trapping seasons established by species. These seasons can vary among the GMUs and between Federal and state regulations, depending on the population of the species in question. For example, on Federal and state lands, there is no closed season for black bears in GMU-25 **(ADF&G 2011a; USFWS 2010b)**. For caribou, open season in GMU-25 is different, depending on the GMU subunit. In portions of GMU-25A, there is no closed season for hunting caribou bulls; however, hunting caribou cows is not permitted between early July and mid-May **(ADF&G 2011a; USFWS 2010b)**. Therefore, subsistence activities occur year-round, depending on the open seasons and availability of the variety of vegetation and wildlife species harvested.

Within the PFFR launch corridor, many subsistence participants rely on fishing for both salmon and non-salmon species, large and small land mammals, and a variety of bird species. Land mammals such as caribou, moose, and Dall sheep in particular are used as sources of meat. Marine mammals can be harvested for subsistence purposes, but only by Alaska Natives, as permitted in the MMPA. The regulations governing subsistence harvests of marine mammals are co-managed by Alaska Natives, USFWS, and NMFS. The Kaktovik community is heavily dependent on the subsistence hunting of marine mammals.

In general, subsistence activities occur year-round, depending on the open seasons and availability of the variety of vegetation and wildlife species harvested. Harvesting vegetation such as berries or other roots or vegetables typically occurs in late summer as the vegetation ripens. Subsistence hunting and trapping are regulated by the hunting and trapping seasons established by species. These seasons can vary among the GMUs and between Federal and state regulations, depending on the population of the species in question. For example, on Federal and state lands, there is no closed season for black bears in GMU-25 **(ADF&G 2011b; USFWS 2010b)**. For caribou, open season in GMU-25 is different, depending on the GMU subunit. In portions of GMU-25A, there is no closed season for hunting caribou bulls; however, hunting caribou cows is not permitted between early July and mid-May **(ADF&G 2011b; USFWS 2010b)**.

3.11 TRANSPORTATION

Alaska Route 3, or Parks Highway, provides road access from the south (Anchorage area) to Fairbanks, Alaska. Alaska Route 2 provides access to Fairbanks from the southeast from Canada. PFRR is accessible from Fairbanks by traveling from Alaska Route 2 on the northeast side of Fairbanks to Alaska Route 6, also known as Steese Highway. PFRR is located off of Steese Highway about 48 kilometers (30 miles) northeast of Fairbanks. Steese Highway is a paved road between Alaska Route 2 and PFRR.

Alaska Route 11, or Dalton Highway, is the main land link between Fairbanks and the Prudhoe Bay oil fields and basically follows the Trans-Alaska Pipeline to the west of the PFRR launch corridor. Alaska Statute prohibits the use of off-road-vehicles within 5 miles of the Dalton Highway right-of-way in the Dalton Highway Corridor Management Area **(USFWS 2011c)**.

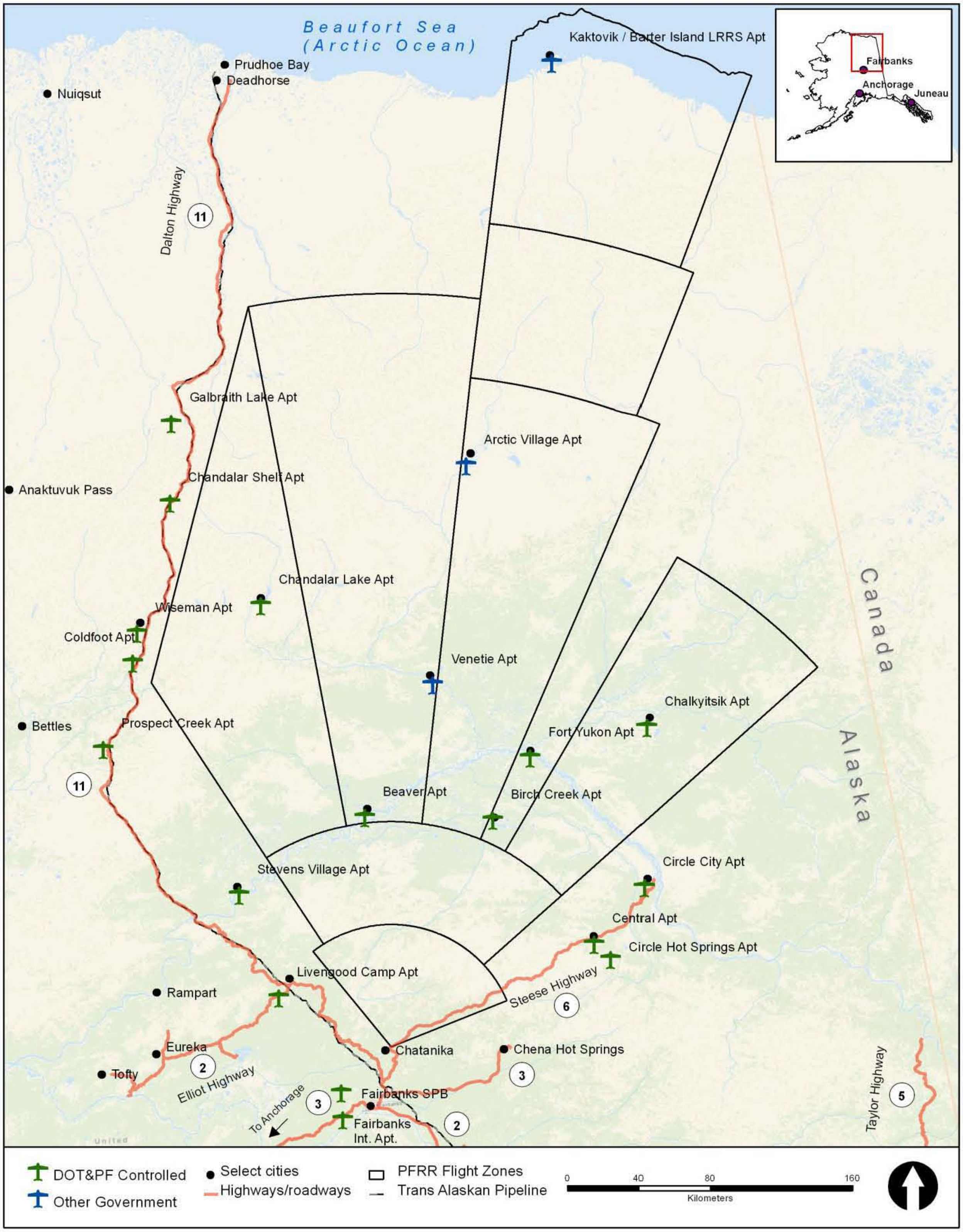
Traffic counts are recorded on Steese Highway north of Fox and annually reported. Between 2007 and 2009, the annual average daily traffic count for this location ranged from 1,500 to 1,800 vehicles, with the traffic equally split for each direction **(ADOT&PF 2010)**. This volume is considered light and free-flowing.

Because of the long distances, remoteness, and climate, much of the state of Alaska is accessible only by general aviation aircraft. The Alaska Department of Transportation and Public Facilities owns 254 airports, with other government airports also present throughout the state. Two of the airports are commercial airports: the Ted Stevens Anchorage International Airport and the Fairbanks International Airport. The Fairbanks International Airport is located on the west side of Fairbanks and provides passenger, cargo, and general aviation services. The remaining 252 state-owned airports are rural airports that have either paved or gravel runways. There are 18 rural airports in or near the PFRR launch corridor, many of which are located along the Dalton Highway/Trans-Alaska Pipeline corridor **(ADOT&PF 2011)**. Three of these airports in the launch corridor are owned by tribal governments (Venetie, Arctic Village, and Kaktovik). Frequency of air service varies, but several communities have regularly scheduled air service, and air-taxi charter services are also available **(USFWS 2011c)**. Light aircraft equipped with either wheels, skis, or floats can be used to access areas that are not near airports, depending upon the season. During summer months, wheel planes can land on some river gravel bars, beaches along the Beaufort Sea coast, and other flat areas to access more remote regions. Floatplanes can access some of the larger lakes **(USFWS 2011c)**. Helicopters can also be used to access areas within the launch corridor.

The Alaska Railroad provides rail access from Anchorage to Fairbanks. **Figure 3–9** shows the primary roads associated with operations at PFRR and commercial and rural airports in or near the launch corridor.

3.12 WASTE MANAGEMENT

This section discusses forms and management of wastes generated or released at the PFRR launch site and within the launch corridor. Hazardous wastes or hazardous materials are substances that are defined as hazardous by the Comprehensive Environmental Response, Compensation, and Liability Act **(42 U.S.C. 9601 *et seq*.)** and the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act **(42 U.S.C. 6901 *et seq*.)**. In general, these substances may present substantial danger to the public health or welfare or the environment when released into the environment because of their quantity, concentration, or physical, chemical, or infectious characteristics or radiation exposure. The ROI for hazardous materials and hazardous waste at PFRR would extend to all locations where these substances are used, stored, transported, or disposed of. Even when disposal does not occur on site, waste generators are responsible for waste disposed of offsite; thus, the ROI encompasses the PFRR launch site and any offsite disposal locations.



Note: To convert kilometers to miles, multiply by 0.6214.

Source: SAIC 2011.

Figure 3–9. Major Roadways and Airports in or Near the Poker Flat Research Range Launch Corridor Area

3.12.1 Hazardous Waste Generation and Storage

The UAF Risk Management Office manages the removal and disposal of hazardous waste **(USA 2001)**. PFRR has conditionally exempt small-quantity generator status (EPA ID No. AKO 0000374959); as such, UAF and PFRR can generate no more than 100 kilograms (220 pounds) of hazardous waste and accumulate no more than 1,000 kilograms (2,200 pounds) of hazardous waste per month **(USA 2001)**. PFRR does not have a Hazardous Waste Contingency Plan or a Spill Prevention Control and Countermeasures Plan because of the small quantity of materials kept on site, so procedures set forth in the UAF Health, Safety and Risk Management Policies are followed **(UAF 2003b)**. The UAF Fire Marshall and Range Safety Officer are responsible for inspecting all hazardous materials storage facilities at PFRR, documenting the findings, verifying corrective actions, and maintaining accurate records. At a minimum, the Range Safety Officer/Hazardous Material Coordinator conducts an annual inventory of hazardous materials and monthly inspections of material storage conditions **(USA 2001)**.

Typical hazardous wastes generated at the PFRR launch site are petroleum, oils, lubricants, battery acid (H_2SO_4), alkalis (potassium hydroxide [KOH]), neon batteries, lithium batteries, alcohols, and acetone. Some payloads may contain explosives or chemicals. PFRR has a 45,000-kilogram (100,000-pound) limit on the storage of explosives **(USA 2001)**. Mission-specific materials (*e.g.*, TMA) are shipped in specialized containers to the launch site on an as-needed basis in only those quantities necessary for the scientific objectives.

There are four aboveground bulk fuel storage tanks at PFRR, as follows: one 19,000-liter (5,000-gallon) diesel tank, one 19,000-liter (5,000-gallon) regular unleaded gasoline tank, one 5,700-liter (1,500-gallon) super unleaded gasoline tank, and one 5,700-liter (1,500-gallon) jet-B fuel tank. Explosives at PFRR are stored in the Explosive Storage Building. Helium is stored outside the Balloon Inflation Building in mobile canisters. All of these facilities are located at the PFRR launch site **(USA 2001)**.

A small diesel spill occurred at the PFRR launch site in December 1999. This contaminated site was cleaned up and listed as "closed" in January 2010, according to the State of Alaska's Contaminated Sites Database **(ADEC 2011)**.

3.12.2 Hazardous Materials Used in Rocket Launches

Hazardous materials, toxic substances, and explosives, which are regulated substances used in launching or part of the payload (scientific experiments), include paints, oils, solvents, photographic and cleaning chemicals, bottled gases and, at times, small quantities of radioactive materials. Some payloads may contain explosives or chemicals **(NASA 2000a; USA 2001)**. Propellants typically include ammonium perchlorate and aluminum or nitrocellulose and nitroglycerine. Chapter 2, Section 2.2, of the *SRP SEIS* **(NASA 2000a)** defines these propellants and their exhaust products in full detail. Rocket motors typically contain insulation materials to protect the rocket case and nozzle from the heat of the burning propellant. A variety of insulation types have been used, including asbestos encapsulated in a resin that partially burns away during rocket motor firing **(Hesh 2011)**. Nickel-cadmium batteries, pressure systems or vessels, and hazardous circuits are also used as part of the stages or payload **(NASA 2009)**.

Chapter 4, Section 4.12 of this *PFRR EIS* provides greater detail, including the typical quantities and potential hazards, of such items commonly used on sounding rockets.

The use of surplus solid propellant rockets, such as Nike, Orion, Taurus, Terrier, and Aries, in the NASA SRP launch vehicles reduces the commitment of new raw materials and provides for the beneficial use of already expended resources that could become hazardous waste. Propellant systems currently used at PFRR are based either on an ammonium perchlorate/aluminum (AP/AL) combination or a nitrocellulose/nitroglycerin (NC/NG) combination. The emissions from the AP/AL propellant combination include hydrogen chloride and aluminum oxide and are generally considered to be more environmentally damaging than emissions from the NC/NG propellant combination **(NASA 2000b)**. The potential impacts on water resources and geology and soils are discussed further in Chapter 4, Sections 4.3 and 4.4.

3.12.3 Existing Stages and Payloads within the Poker Flat Research Range Launch Corridor

As shown in **Table 3–18**, past NASA SRP launch operations from PFRR have resulted in the deposition of approximately 680 stages and payloads (estimated based on launch information in **UAF 2011a**). Fifty payloads have been recovered, and an estimated 78 spent stages have been recovered from the launch corridor and returned to the PFRR launch site for disposal (estimated based on information in **UAF 2011a**). Therefore, approximately 550 NASA spent stages and payloads are estimated to remain in the launch corridor. Non-NASA items estimated to remain in downrange lands are discussed in Chapter 4, Section 4.15.11 of this *PFRR EIS*.

Table 3–18. Spent Stages and Payloads Launched by NASA into the Poker Flat Research Range Launch Corridor

Area Within Launch Corridor	Number of Spent Stages	Number of Spent Payloads
ADNR Poker Flat North and South Special Use Areas	202	1
White Mountains National Recreation Area	50	43
Mainly in Yukon Flats NWR	46	46
Arctic NWR, Native Village of Venetie Lands, and ADNR lands	127	93
Beaufort Sea/Arctic Ocean	34	34
Unknown	2	1
Subtotal	461	218
Less Recovered	(78)	(50)
Estimated Total	**383**	**168**

Key: ADNR=Alaska Department of Natural Resources; NWR=National Wildlife Refuge.

3.12.4 Waste Treatment and Disposal Practices

Recovered stages are cleaned per Local Work Instruction BM54138, which includes the inspection, removal, and steam cleaning of contaminated residue/materials within the rocket motors **(Cornwell 2005)**. Hazardous materials that could be encountered during cleaning include spent fuel residue, asbestos insulation, paint, and batteries. Pressure washing of the spent stages generates rinsate that would be considered hazardous and is disposed of through the Environmental Health and Safety Risk Management Department at PFRR **(UAF 2011)**. The cleaned stages and other nonhazardous waste are disposed of or recycled at the Fairbanks North Star Borough's landfill.

3.13 HEALTH AND SAFETY

3.13.1 Occupational Health and Safety at Poker Flat Research Range

PFRR is owned by UAF and operated by the Geophysical Institute under a contract with NASA. PFRR operates under the health and safety policies and procedures of the University of Alaska, the Federal Occupational Safety and Health Administration's industrial and occupational safety rules and regulations, and the State of Alaska Occupational Safety and Health standards **(UAF 2011a, 2011b)**. UAF developed internal safety policies and the PFRR Health and Safety Plan **(UAF 2011b)** to address specific challenges associated with working with equipment and procedures specific to sounding rocket launches.

During periods when rockets are not being assembled and readied for launch, the number of personnel at PFRR is limited and typically consists of UAF and maintenance and support contractors.

During periods when launch preparations are under way, personnel from the NASA SRP also are present at PFRR. In addition, visiting scientists associated with the launch may also be present. The *NASA Sounding Rocket Program Handbook* **(NASA 2005)** lays out the roles and responsibilities for all parties. NASA personnel and all rocket and launch activities also fall under NASA health and safety policies and procedures. These policies include typical occupational health and safety requirements in addition to specific requirements associated with the handling of rocket components and hazardous materials and the launch of sounding rockets.

Operations and launches at PFRR are conducted in accordance with NASA guidelines and procedures. *NASA Wallops Flight Facility Occupational Safety and Health Manual* requirements **(NASA 2006)** apply to NASA SRP rocket preparation and launch operations at PFRR. Prelaunch and launch operations are conducted in accordance with standard hazardous procedures used by NASA Sounding Rocket Operations Contract (NSROC) and WFF.

3.13.2 Public Health and Safety Within Poker Flat Research Range Launch Corridor

The public is protected from the impacts of sounding rockets and their components through the safety policies and practices of NASA and SRP. The primary policies that protect the public are encompassed in the Range Safety Program and NASA's *Range Safety Manual* **(NASA 2008)**. These range safety policies and practices are consistent with similar range safety requirements of other Federal agencies. These range safety policies and practices ensure that the probability of an accident that impacts the public is extremely low. See Chapter 4, Section 4.13 for additional detail on probabilities of an accident.

All NASA SRP first-stage spent rockets launched from PFRR land between 0.3 and 1.5 kilometers (0.2 and 0.9 miles) from the launch pad with impact weights in the 270- to 800-kilogram (600- to 1,800-pound) range. The small weather and test spent rockets (with an impact weight of 7 to 9 kilograms [15 to 20 pounds]) land between 2.8 and 5.5 kilometers (1.7 and 3.4 miles) from the launch pad. Therefore, an area with a radius of 1.5 to 5.5 kilometers (0.9 to 3.4 miles), depending on the mission, is cleared around the launch pad to prevent injury or damage to personnel or facilities.

3.13.3 Poker Flat Research Range Safety Process

The NASA Goddard Space Flight Center (GSFC) WFF and NSROC team provide mission management and engineering support. All personnel working directly with or in support of the NASA SRP are required to comply with Federal, state, and NASA health, safety, and environmental regulations and procedures applicable to the operation being performed.

The NASA Range Safety Officer, the NSROC Mission Manager, the WFF Project Manager, and the NASA Operations Safety Supervisor share responsibility (within the limits of their jurisdiction) for the safe performance of operations associated with a NASA SRP mission.

All NASA SRP missions are required to prepare both Ground and Flight Safety Plans to minimize risk to human life, property, and natural resources. The Ground Safety Plan identifies the hazardous systems, which exist on the NASA vehicle/payload, and defines the NASA safety category for each hazardous system. Depending on the safety category during various launch operations, restrictions may be imposed on NASA personnel, NASA contractors, and experimenters.

The NASA Range Safety Officer and NASA Operations Safety Supervisor are responsible for ensuring implementation of the Flight and Ground Safety Plans and mission team compliance with these requirements and that there are no violations of the NASA safety requirements, as stated in the GSFC WFF Range Safety Manual **(NASA 2008)**.

A Flight Safety Risk Assessment is also prepared for each mission. Both impact and overflight criteria are considered in the Flight Safety Plans and, while risk cannot be entirely eliminated, they are reduced to an acceptable margin. All flights must be designed so that the impact or reentry of any part of the launch vehicle over any landmass, sea, or airspace will not produce a casualty expectancy of 10^{-6} unless a Safety Analysis Report is prepared or one of the following conditions are met: (l) the reentry vehicle will be completely consumed by aerodynamic heating; (2) the momentum of the solid pieces reentering the atmosphere will be reduced to a degree which precludes injury or damage; or (3) a formal agreement is reached with the landowners to allow the use of the landmass for impact or reentry **(NASA 2008)**.

At all times, there is strict adherence to the NASA GSFC WFF Safety Manual. All launches are evaluated on an individual basis. NASA and UAF use a variety of safety criteria to evaluate launch parameters and potential risks associated with each launch. The criteria are evaluated for each mission and considered by UAF and NASA in making the decision on whether to proceed with the mission and launch. Details of the PFRR safety processes and operations are provided in Chapter 2, Section 2.1.6.

3.13.4 NASA Sounding Rocket Program at Poker Flat Research Range Accident History

3.13.4.1 *Poker Flat Research Range Occupational Injuries*

The most prominent health and safety metric is the accident rate. A strong, effective program has the potential to limit the occurrence of accidents and keep what incidents do occur to minor consequences. The last major accident at PFRR occurred in the early 1980s. No accidents resulting in lost work days have occurred since 2005. The last accident that occurred at PFRR was in 2009. The accident involved a slip on ice resulting in a sprained ankle and a trip to the doctor.

All reportable accidents are captured in a report that is submitted through the UAF Geophysical Institute's Operations Office. None of these injuries were Occupational Safety and Health Administration recordable injuries **(UAF 2011b)**.

3.13.4.2 *NASA Sounding Rocket Program at Poker Flat Research Range Rocket Failures*

NASA sounding rockets have maintained a historical success rate of 87 percent **(NASA 2005)**. A successful flight is defined as one that meets the minimum success criteria. When the minimum success criteria for any given flight are not met, the flight is officially considered a failure **(NASA 2005)**. While operations at PFRR have been quite safe, there have been launches with malfunctions in which the rockets did not perform as expected (see **Table 3–19**). Of 219 NASA SRP launches at PFRR since 1971, 14, or 6.4 percent of the total launched, had some sort of vehicle failure that resulted in failure of the mission and the experiment **(UAF 2011a)**. In general, these failures resulted in some portion of the rocket stage or payload landing in a location other than its planned impact point. All stages and rocket components did; however, land within the PFRR launch corridor. Limited data are available regarding early NASA failures; no detailed records of the approximately 10 non-NASA rocket failures are available. The available information is presented below.

Table 3–19. Rocket Failure History at Poker Flat Research Range

Launch Date	Mission Number	Vehicle Type	Organization	Cause	Landing
March 19, 1971	18.094	Nike-Tomahawk[a]	University of Alaska	Unknown	Unknown
October 13, 1972	14.506	Nike-Apache[a]	GCA	Unknown	Unknown
April 4, 1975	18.172	Nike-Tomahawk[a]	GSFC	Second stage failure at T+21 sec.	Unknown
September 30, 1976	18.180	Nike-Tomahawk[a]	GSFC	Ceramic nosecone shattered at T+14 sec.	Unknown

Table 3–19. Rocket Failure History at Poker Flat Research Range (*continued*)

Launch Date	Mission Number	Vehicle Type	Organization	Cause	Landing
January 18, 1977	29.004	Terrier-Malemute	University of Wisconsin	Unknown	Unknown
January 26, 1979	29.013	Terrier-Malemute	Rice University	Unknown	Unknown
April 15, 1982	35.003	Black Brant X	GSFC	Second stage casing ruptured at T+31 sec.	White Mountains NRA
March 7, 1987	35.018	Black Brant X	University of California at Berkeley	Second stage casing ruptured at T+20 sec.	Unknown
October 20, 1988	33.049	Taurus-Orion	University of Colorado	Second stage failed to ignite	ADNR Poker Flat Special Use
April 30, 1991	31.080	Nike-Orion[a]	University of Pittsburg	First stage fins broke off	Unknown
January 27, 1993	40.003	Black Brant XII	University of New Hampshire	Unknown	Unknown
March 7, 1994	31.071	Nike-Orion[a]	University of Houston	Premature ignition of second stage	Unknown
March 27, 2003	41.028	Terrier-Orion	Clemson University	Second stage did not separate properly	White Mountains NRA
March 6, 2005	40.017	Black Brant XII	Dartmouth	Third stage failed to ignite	White Mountains NRA

a. Rocket platform no longer in service.
Source: Truitt 2011.

3.14 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

This section addresses the existing socioeconomic conditions and characteristics in the ROI. The area most likely to experience socioeconomic impacts from PFRR operations is the area that supplies the majority of the inputs required for the facility’s operation. All of the employees at PFRR reside within the Fairbanks North Star Borough. PFRR employs 13 full-time employees, 2 part-time employees, and 6 seasonal employees. PFRR is host to approximately 35 visiting scientists and payload personnel during launch operations, whose accommodations are also within the Fairbanks North Star Borough. The vast majority of labor at PFRR is supplied from within the Fairbanks North Star Borough; therefore, the Fairbanks North Star Borough is the ROI for this socioeconomic analysis.

3.14.1 Population and Housing

From 2000 to 2010, the population of Fairbanks North Star Borough increased approximately 18 percent to 97,581. Over the same period of time, the population of Alaska increased approximately 13 percent to 710,231 **(Census 2001a, 2011)**. In 2010, the minority population of the ROI and the State of Alaska constituted approximately 25.9 percent and 35.9 percent of the total population, respectively **(Census 2001a, 2011)**. Comparatively, the total minority population percentage of the ROI and Alaska is very similar to that of the United States (approximately 36.3 percent). **Table 3–20** displays the demographic characteristics of Fairbanks North Star Borough and the State of Alaska.

Table 3–20. Demographic Composition of Fairbanks North Star Borough and the State of Alaska

Population	Fairbanks North Star Borough	Percentage of Total Population	Alaska	Percentage of Total Population
Total Population	**97,581**	**100.0**	**710,231**	**100.0**
White non-Hispanic	72,259	74.1	455,320	64.1
Total Minority Population	**25,322**	**25.9**	**254,911**	**35.9**
Black or African American[a]	4,423	4.5	23,263	3.3
American Indian and Alaska Native[a]	6,879	7.0	104,871	14.8
Asian[a]	2,591	2.7	38,135	5.4
Native Hawaiian and other Pacific Islander[a]	396	0.4	7,409	1.0
Some other race[a]	1,446	1.5	11,102	1.6
Two or more races[a]	6,671	6.8	51,875	7.3
White Hispanic[a]	2,916	3.0	18,256	2.6
Hispanic or Latino (of any race)[b]	5,651	5.8	39,249	5.5

a. Includes persons self-identified as Hispanic or Latino.

b. Includes all persons self-identified as Hispanic or Latino, regardless of race.

Source: Census 2011.

The number of housing units in Fairbanks North Star Borough increased approximately 26 percent to 41,783 between 2000 and 2010, slightly faster than the population growth rate **(Census 2001b, 2011)**. Both the homeowner vacancy rate and the renter vacancy rate of the borough were higher than that of Alaska. A large portion of vacant housing in the ROI and Alaska is for seasonal, recreational, or occasional use and therefore is not included in the homeowner or rental inventory **(Census 2011)**. Housing characteristics of the ROI and Alaska are presented in **Table 3–21**.

Table 3–21. Housing Characteristics of the Region of Influence and the State of Alaska

Housing Characteristics	Fairbanks North Star Borough	Alaska
2000 Housing units	33,291	260,978
2010 Housing units	41,783	306,967
Percentage change	26	18
Vacant	5,342	48,909
Seasonal	1,676	27,901
Vacant units for sale	509	2,876
Owner-occupied units	21,502	163,771
Homeowner vacancy rate	2.3	1.7
Vacant units for rent	1,502	6,729
Renter-occupied units	15,110	95,960
Renter vacancy rate	9.0	6.6

Source: Census 2001b, 2011.

3.14.2 Regional Economic Characteristics

Total government (Federal, state, and local) was the largest employment industry in the Fairbanks North Star Borough, accounting for 31.2 percent of all employment in 2010. The largest private sector industry in the Fairbanks North Star Borough was education and health services, accounting for 12.7 percent of total employment, followed by retail trade at 11.8 percent **(DOLWD 2011a)**. The largest employers in the Fairbanks North Star Borough are the University of Alaska, the Fairbanks North Star School District, and the State of Alaska **(DOLWD 2011b)**.

As of July 2011, the unemployment rate of the Fairbanks North Star Borough was 6.1 percent. Similarly, the statewide unemployment rate of Alaska was 6.9 percent **(DOLWD 2011c)**. By comparison, the unemployment rate of the United States, 9.1 percent in July 2011, is much higher than that of the ROI or Alaska **(BLS 2011a)**. In 2009, the median income of the Fairbanks North Star Borough and the State of Alaska was $28,234 and $28,739, respectively.

3.14.3 Environmental Justice

The goal of environmental justice from a Federal perspective is to ensure fair treatment of people of all races, cultures, and economic situations with regard to the implementation and enforcement of environmental laws and regulations and Federal policies and programs. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (and the February 11, 1994, Presidential Memorandum providing additional guidance for this Executive Order) requires Federal agencies to develop strategies for protecting minority and low-income populations from disproportionate and adverse effects of Federal programs and activities. Minority and low-income populations are typically defined by comparing the demographics of potentially affected communities to those at the state, county, or local levels. The assessment of potential effects encompasses a broad range of resources, including those of the physical or natural environment and interrelated social, cultural, and economic factors.

To ensure compliance with Executive Order 12898, NASA prepared an Environmental Justice Implementation Plan (EJIP) in 1996 for activities managed by WFF, including those at remote sites such as PFRR. In the EJIP, NASA committed to incorporating environmental justice considerations in all its activities. A key component of NASA's environmental justice program is its continuing outreach activities. During project planning, NASA regularly holds public meetings and issues announcements to ensure that members of the public are aware of upcoming activities. These announcements are published through a variety of outlets, including the Internet, local radio, local (free) newspapers, and local town hall meetings. This outreach effectively ensures that people of all incomes and ethnicities have the opportunity to provide input on NASA's activities.

3.14.3.1 *Potentially Affected Communities*

A total of nine Alaska Native communities are located within or immediately adjacent to the launch corridor: Arctic Village, Beaver, Birch Creek, Chalkyitsik, Circle, Fort Yukon, Kaktovik, Stevens Village, and Venetie. These communities are discussed in detail in Section 3.9.3.4. The city of Chandalar has also been identified as within the launch corridor; however, very little information is available for this area as it is not an officially recognized place. **Table 3–22** displays population characteristics of the Alaska Native communities, the Fairbanks North Star Borough, and Alaska.

Table 3–22. Population Characteristics of Potentially Impacted Alaska Native Communities, the Fairbanks North Star Borough, and the State of Alaska

Alaska Native Village	Population in 2000	Population in 2010	Percentage Change	Alaska Native Population in 2000	Alaska Native Population in 2010	Alaska Native Population as a Percentage of Total Population	Percent Low-Income Population
Arctic Village	150	150	0	131	135	89	37
Beaver	84	84	0	72	82	98	34
Birch Creek	28	33	18	28	33	100	50
Chalkyitsik	83	69	–17	81	59	86	23
Circle	100	104	4	76	88	85	45
Fort Yukon	600	580	–2	510	520	89	18
Kaktovik	290	240	–18	220	210	89	10
Stevens Village	87	78	–10	83	66	85	16
Venetie	202	150	–26	190	140	91	26
Fairbanks North Star Borough	83,000	98,000	18	5,700	6,900	7.0	7.8
Alaska	630,000	710,000	13	98,000	105,000	15	9.0

Source: Census 2001a, 2010a, 2010b, 2011.

The total populations of most of these areas decreased between the 2000 and 2010 census, a few remained stable, and one community, Birch Creek, increased. Demographically, the proportion of minority and low-income people within the populations of these communities is high. As can be seen in the above table, the Alaska Native population constitutes the majority of the total population of these villages **(Census 2001a, 2011)**. Homeowner vacancy rates in all of the Alaska Native communities listed above are essentially zero. Similarly, renter vacancy rates for most of the communities are also zero. Arctic Village, Beaver, Fort Yukon, and Venetie all have renter vacancy rates higher than the Fairbanks North Star Borough and Alaska. However, the higher rates are primarily due to a small rental inventory and not a large number of vacant units **(Census 2011)**.

Both the median income and per-capita income of the potentially affected Alaska Native communities are much lower than those of the Fairbanks North Star Borough and Alaska. **Table 3–23** displays income characteristics of the native communities, the Fairbanks North Star Borough, and the State of Alaska. Most native communities exhibit a per-capita income that is much higher than the median income. This is an indication of higher-than-average unemployment and a large percentage of the working population employed in the public sector.

Table 3–23. Income Characteristics of the Potentially Affected Alaska Native Communities, the Fairbanks North Star Borough, and the State of Alaska

Location	Median Income	Per-Capita Income
Arctic Village	6,806	9,893
Beaver	6,641	12,267
Birch Creek	13,750	9,821
Chalkyitsik	12,019	19,761
Circle	2,917	13,503
Fort Yukon	17,468	19,254
Kaktovik	15,750	19,022
Stevens Village	10,982	20,437
Venetie	8,542	11,236
Fairbanks North Star Borough	28,234	28,482
Alaska	28,739	29,504

Source: Census 2010c, 2010d, 2010e, 2010f.

Villages, towns, and cabins are considered “special protection zones” during rocket mission planning and operations. Some villages have individual agreements with UAF (*e.g.*, Venetie and Arctic Village) and receive monetary compensation if the probability of a rocket landing on native property is above a stated threshold. The village of Fort Yukon is a “no fly zone.”

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CHAPTER 4

ENVIRONMENTAL CONSEQUENCES

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4. ENVIRONMENTAL CONSEQUENCES

Chapter 4 of this environmental impact statement assesses and compares the potential environmental consequences of the alternatives described in Chapter 2.

In addition to providing an assessment of direct and indirect impacts of each alternative, this chapter also contains a cumulative effects assessment, which outlines the resulting effects on each resource when added to the effects of past, present, and reasonably foreseeable actions within each resource area's region of influence.

For a summary of the major findings documented in this Chapter, see Chapter 2, Table 2–12, which is the summary table of environmental consequences.

The National Aeronautics and Space Administration (NASA) Sounding Rockets Program (SRP) operations at Poker Flat Research Range (PFRR) consist principally of a series of suborbital rocket flights followed by recovery actions.

In general, each SRP launch at PFRR typically entails the following programmatic components that could result in environmental effects and are therefore considered within this Chapter of the environmental impact statement (EIS):

1. Preflight activities, including receiving, storing, and inspecting rockets and assembling the scientific payload;

2. Assembling rockets and scientific payload to make up the launch vehicle, transporting the launch vehicle to the launch pad, mounting the vehicle to the launcher, and pointing the launcher;

3. Releasing small meteorological balloons, which have payloads recording data on upper-atmospheric weather conditions;

4. Series launching of two small test rockets nearby for radar and telemetry checkout/calibration;

5. The actual launching of the sounding rocket and surface-to-surface flight, lasting a matter of minutes;

6. Immediate post-flight activities, including, in some cases, recovery of the payload and spent stages, and storing of the launch equipment; and

7. Longer-term closure activities, such as removing identified spent stages and payloads from downrange impact sites, and restoring these sites to their original condition.

How Impacts are Described in this EIS

Project-related environmental impacts are described by their type, context, intensity, and duration for each affected resource area. The levels of impacts and their specific definitions vary based on the resource that is being evaluated. For example, the scale at which an impact may occur (local, regional, etc.) would be different for wetland impacts as compared to economic resources. Moreover, an otherwise minor impact occurring within a sensitive area could be considered major given the environmental context.

Table 4–1 provides a general overview of how potential impacts are evaluated in this EIS. Specific considerations that are only applicable to a resource area are described within its respective section.

Table 4–1. Evaluation Criteria for Analyzing Environmental Impacts

Type of Impact	
Adverse	The impact would result in some level of environmental degradation.
Beneficial	The impact would result in some level of environmental improvement.
Context of Impact	
Local	The impact would not extend beyond the immediate vicinity of the action causing the effect.
Regional	The impact would occur over a larger geographic scale, such as an ecoregion.
Global	The impact would occur at the global level.
Intensity of Impact (how much)	
Major	Substantial impact on or change in a resource area that is easily defined, noticeable, and/or calculable but may not be measurable, or exceeds a threshold level that may threaten the integrity of one or more resource components.
Moderate	Noticeable change in a resource occurs, but the integrity of the resource remains intact.
Minor	The impact is at the lowest levels of detection (barely measurable and with no perceptible consequences) or would result in only a minor change in a resource.
Negligible	Impact is at the lowest level of measurement or is so low as to be immeasurable and has no perceptible consequences.
Duration of Impact (how long)	
Long-Term	The impact would likely persist for a period greater than the medium-term impact and, depending on the specific resource and project type, would likely extend beyond the life of the project.
Medium-Term	The impact would only occur for specific, relatively brief periods during the project life, interrupted by periods of no impacts (for example, during recovery operations).
Short-Term	The impact would extend for short periods much less than the overall project life (for example, during launch operations).

Assumptions

The characteristics (*e.g.*, launch vehicle, trajectory, and payload) and frequency of missions conducted at PFRR are highly dependent upon the scientific objectives of the sponsoring researcher and NASA's scientific priorities. Therefore, it is not possible to assess every possible mission scenario that could be proposed for PFRR in the next 10 years.

Accordingly, NASA made certain assumptions regarding the types of rocket, payload, and recovery operations that would most likely occur; these were based primarily upon past experience, interviews with key personnel, and best professional judgment. These assumptions are detailed in Appendices F and G; however, the key overarching assumptions for assessing impacts are listed below:

- Future launches from PFRR would consist primarily of two- and four-stage rockets (the Terrier-Improved Orion [T-IO] and the Black Brant [BB] XII);

- Launch frequency would average four launches per year, not exceeding eight in any given year;

- Launch trajectories would be similar to those flown over the past 10 years;

- Launches would occur during winter months (December–April); and

- Recovery operations would occur during non-winter months (May–September) unless necessitated by a safety requirement or scientific need.

Additional assumptions that are only useful for assessing the effects on a particular resource area are presented in its respective methodology section.

It is important for the reader of this *Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* to recognize that recovery efforts would only be undertaken if a post-launch (or post-report in the case of an existing stage or payload identified by a person or group not related to PFRR operations) search flight resulted in the positive identification of NASA SRP associated hardware. In the case of newly launched hardware, recent searches have resulted in the identification of approximately half of the known items. This success rate is expected to increase as location devices are improved; however, the reader should not assume that all downrange flight hardware would be found in every case. Therefore, the most reliable (and conservative) product of the assumptions outlined in Appendix F is an estimated quantification of fuel usage (and resulting air emissions) of recovery-related vehicles. Estimates of flight times (and fuel usage) associated with both search and recovery would be considered conservative in that greater emissions would occur when conducting both activities. This would also be the case for noise, in which removal activities would generate more human-induced sounds into the natural environment. However, when other resource areas, such as the wilderness values of special use lands, are considered, these scenarios may underestimate impacts in that it is likely not all hardware would be removed. Therefore, a range of potential outcomes could result, and the reader should be aware that when appropriate, these ranges are presented for consideration.

How Probability is Considered

The analysis of several key resource areas, including wildlife, land use, and safety, rely heavily on numerical probabilities of flight hardware landing within a particular area of interest. During both pre-mission planning and in real time during the launch sequence, NASA calculates the estimated impact points for the sounding rocket stages and the payloads based on information known about the launch (*e.g.*, azimuth, payload weight, direction, and wind speed). While these calculations provide NASA's best estimates of where these items are expected to impact the Earth, there is a level of uncertainty associated with these estimates because of the large number of variables associated with each launch (explained in more detail in Chapter 2, Section 2.1). These variations become even more pronounced the higher the payload or spent stage is launched.

Each mission employs a specific trajectory and it is not practical to estimate potential future impacts from each specific past mission. Evaluation of past launch data, however, can identify trends and areas most likely to be affected by future launches, resulting in a more focused analysis. For this EIS, typical impact locations were established at seven different distances from the PFRR launch site, covering a range of possible launch vehicles, to determine the probability of a spent stage or payload landing within a number of potential areas of concern (see Appendix G) and to develop search and recovery scenarios (see Appendix F). These impact points represent composite points for a number of rocket launches from PFRR over the years. They are not intended to represent the predicted impact points for all future NASA SRP launches from PFRR, but are intended to show where future launches are most likely to occur and to graphically illustrate the typical uncertainty, or dispersion, associated with the most common vehicles. The distances established are as follows:

- 2 kilometers (1.2 miles) – 1st stage of BB IX or BB XII
- 13 kilometers (8.1 miles) – 1st stage of T-IO or 2nd stage of BB XII
- 55 kilometers (35 miles) – Orion
- 200 kilometers (120 miles) – 2nd stage of Mark 12 T-IO
- 300 kilometers (180 miles) – 2nd stage of BB IX or BB X
- 350 kilometers (220 miles) – 3rd stage of BB XII or 2nd stage of Mark 70 T-IO
- 1,000 kilometers (620 miles) – 4th stage of BB XII

These areas are shown below in **Figure 4–1**. More information regarding this methodology is contained within Appendix G.

How this Chapter is Organized

Similar to Chapter 3 of this EIS, Chapter 4 is organized by resource area. For each resource, a brief introduction is provided, followed by a summary of the analytical methodology and specific assumptions used to support the analysis, and then concluding with a presentation of impacts for each alternative. Where relevant, impacts of each alternative on a resource are presented by the phase of operations to which they correspond (*e.g.*, launch or search and recovery).

Consideration of Non-Winter Launches

For some resource areas, a general discussion of potential impacts occurring from non-winter launches is presented. Although non-winter launches have not occurred within recent years, and are not expected to occur, the potential for their proposal cannot be completely discounted. Therefore, a high-level assessment of potential effects and necessary considerations is provided as a means to identify relevant issues that would need to be addressed should the need for such an operation arise. Given only the cursory level of assessment of potential effects in this *PFRR EIS*, especially those related to wildfire, any future proposals for non-winter launches would require more focused, mission-specific National Environmental Policy Act (NEPA) assessment, as appropriate.

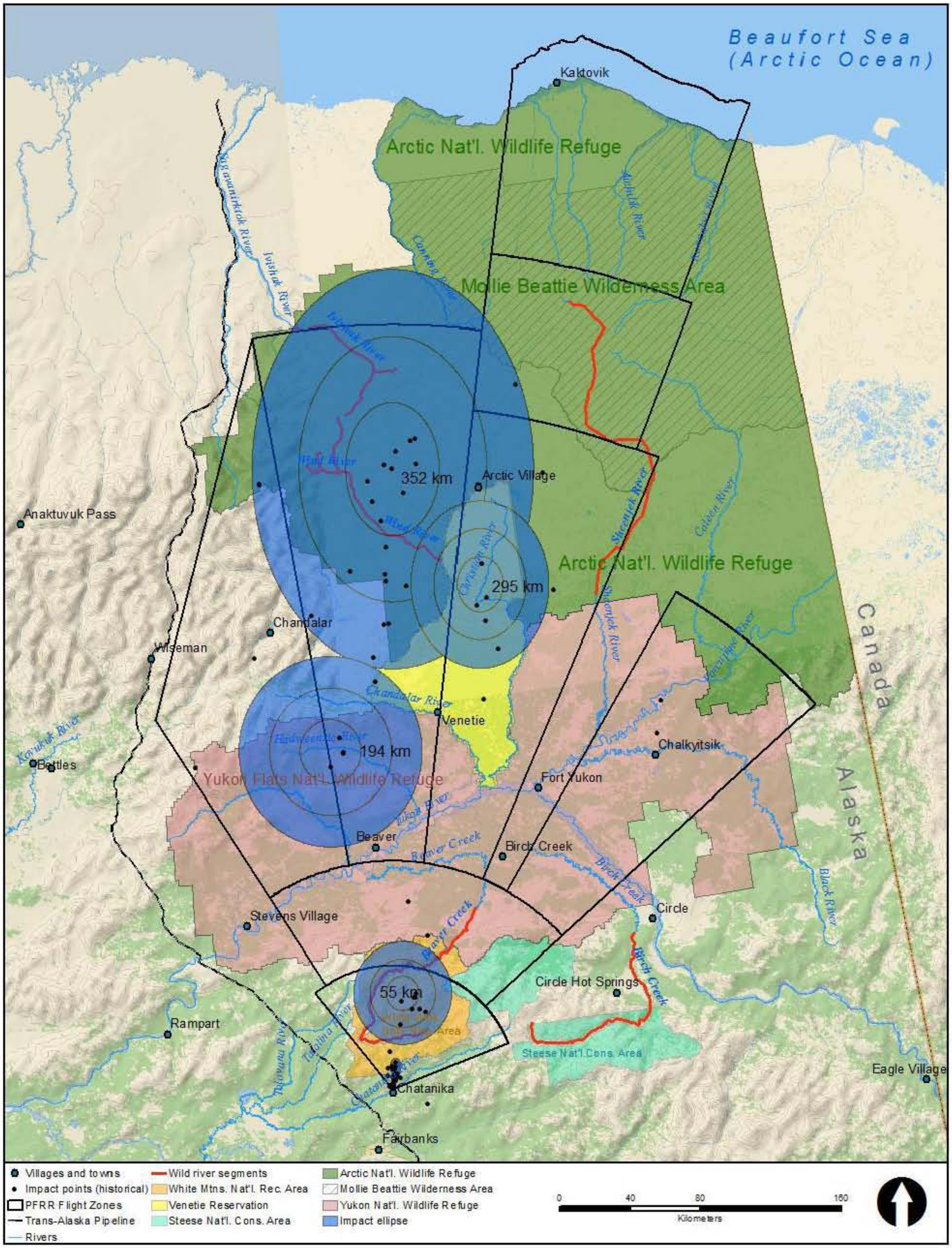


Figure 4–1. Typical Landing Areas Established for Analysis of Impacts

4.1 AIR QUALITY

This section describes potential impacts on air quality in and around PFRR and under the launch corridor as a result of the alternatives.

4.1.1 Methodology

Under the Clean Air Act (CAA), emissions of stationary sources are regulated through emission standards for certain categories of sources and permitting programs for new and modified sources. Emissions from mobile sources (*e.g.*, cars and trucks) are regulated through standards for fuel production and vehicle efficiency. Mobile sources such as sounding rockets; however, are not regulated by the CAA.

PFRR activities that may affect air quality include conducting routine site operations (*e.g.,* heating of buildings, use of electricity), use of employee vehicles and delivery vehicles, rocket launches, and search and recovery activities. Emissions from ongoing, routine activities at PFRR were quantified based on recent fuel and electricity use (see Chapter 3, Section 3.1). Emissions from sounding rocket launches were quantified for vehicles that are expected to be used the most frequently in the future. Emissions from rocket launches vary depending on the launch vehicle, but typically include emissions of carbon dioxide, carbon monoxide, nitrogen dioxide, aluminum oxide, and other particulate matter. Emissions from launches analyzed in this *PFRR EIS* were estimated assuming up to four launches of BB XII rockets (see **Table 4–2**) and four launches of T-IO rockets (see **Table 4–3**) per year. Although other launch vehicles may be used at PFRR, the number of launches and amount of emissions in any year are expected to be less than the total emissions from this combination.

Table 4–2. Black Brant XII Rocket Launch Air Pollutant Emissions (kilograms)

Pollutant	Stage 1[a] (Talos) (0.2 to 1.9 km)	Stage 2[a] (Taurus) (4.2 to 6.3 km)	Stage 3[b, c] (Black Brant V) (10.6 to 58.9 km)	Stage 4[b, c] (Nihka) (96.0 to 153.5 km)	Total
Carbon dioxide	469	175	14	9	667
Carbon monoxide	465	333	228	66	1,092
Lead	22	11	0	0	33
Hydrogen chloride	0	0	187	67	254
Aluminum oxide	0	0	357	106	463
Sulfur	0	0	1	1	2
Other	0	0	4	2	6

a. Emissions from Stages 1 and 2 are to the lower atmosphere.
b. Emissions from Stages 3 and 4 are to the upper atmosphere.
c. Aluminum oxide would be emitted as particulate matter.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Key: km=kilometers.
Source: NASA 2000a.

Table 4–3. Terrier-Improved Orion Rocket Launch Air Pollutant Emissions (kilograms)

Pollutant	Stage 1[a] (Terrier) (0 to 1.5 km)	Stage 2[b] (Orion) (10 to 52 km)	Total
Carbon dioxide	160	44	204
Carbon monoxide	228	50	278
Lead	10	0	10
Hydrogen chloride	0	64	64
Aluminum oxide[c]	0	31	31
Sulfur	0	1	1
Copper	0	1	1
Other	0	0	0

a. Emissions from Stage 1 are to the lower atmosphere.
b. Emissions from Stage 2 are to the upper atmosphere.
c. Aluminum oxide would be emitted as particulate matter.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Key: km=kilometers.
Source: NASA 2000.

Emissions from search and recovery activities were based on the estimated number of helicopter and airplane flights per year for each alternative; flight time required for search and recovery in various areas, as described in Appendix F; typical emissions for hourly operation of this equipment; and emissions for landing and takeoff operations. Aircraft emission rates were obtained from the Federal Aviation Administration's EDMS [Emissions and Dispersion Modeling System] program for aircraft emissions **(FAA 2010)**. Emissions for truck transport and fuel delivery operations during recovery operations were based on miles traveled and emission rates obtained from the U.S. Environmental Protection Agency's (EPA) Mobile 6.2 emission factor model for vehicles **(USEPA 2003)**.

For the evaluation of magnitude of air quality impacts, major impacts would be any that result in concentrations that exceed ambient standards and result in degradation of air quality in a nonattainment area.[1] Moderate impacts would be any that result in an increase in ambient concentrations of more than 10 percent of the ambient standard; or an increase in toxic pollutant concentrations above a guideline level. For mobile source emissions, a moderate impact would equate to an increase in emissions greater than 250 tons (230 metric tons) per year for any criteria pollutant. This value is used by the EPA in its New Source Review standards as an indicator for impact analysis for listed new major stationary sources in attainment areas. No similar regulatory threshold is available for mobile source emissions. Lacking any mobile source emissions thresholds, the 250-ton-per-year (230-metric-ton-per-year) per year major stationary source threshold was used to equitably assess and compare mobile source emissions.

1 A nonattainment area is an area that the U.S. Environmental Protection Agency has determined does not meet one or more of the National Ambient Air Quality Standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may meet the standards for some pollutants, but not for others.

Minor impacts would be any that result in increases of pollutant that are less than the levels specified as moderate impacts, but greater than negligible impacts, which are immeasurable.

For the evaluation of duration of air quality impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as emissions from routine operations at PFRR or the impact from ozone-depleting substances.

4.1.2 No Action Alternative

4.1.2.1 *Launch Operations*

Emissions from a sounding rocket in the lower atmosphere occur over a few seconds. When launches occur during the winter, which is normally the case at PFRR and is assumed to be the case for new launches from PFRR over the next 10 years, the winds are typically from the northeast from 6.4 to 8.0 kilometers per hour (4 to 5 miles per hour) **(NASA 2000a)**. These winds are not strong enough to result in pollutant concentrations high enough to be of concern at sensitive receptors 1.6 kilometers (1 mile) or more to the south (Chatanika Lodge and F.E. Gold Camp). Emissions of a launch of a BB XII or a T-IO would result in emissions of particulate matter (primarily aluminum oxide), carbon monoxide, and carbon dioxide, as shown in Tables 4–2 and 4–3. The BB XII launch vehicle has the highest emissions of the sounding rockets used at PFRR. Other vehicles used at PFRR would have lower emissions and lower impacts on nearby receptors. Based on this analysis, launching any sounding rocket shown in Chapter 2, Figure 2–2, from PFRR would result in ground-level air pollutant concentrations below the ambient air quality standards.

Emissions from daily activities at PFRR include the operation of heating and ventilation systems, occasional operation of generators, use of various vehicles to move equipment, and employee vehicles. Estimated annual emissions from these activities are presented in Chapter 3 and are expected to be similar under all the alternatives. Annual emissions from rocket launches are presented in **Table 4–4**, assuming up to 4 BB XII launches and 4 T-IO launches per year. Although other launch vehicles may be used, the total emissions are not expected to exceed the total associated with these launch vehicles.

Air quality impacts from PFRR routine operations would be regional in scope, adverse, however minor and long-term in duration. Impacts from rocket launches would be global in scope, adverse, and minor and short-term in duration.

Annual emissions from recovery activities would be limited to attempted recovery of up to one payload under the No Action Alternative, as discussed in Appendix F. Annual emissions from search and recovery operations are presented in Table 4–4. Impacts from search and recovery operations would be regional in scope and adverse; however, minor and medium-term in duration.

Table 4–4. No Action Alternative Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation a	Launches b	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	0.2	21
Nitrogen dioxide	6.9	0	<0.1	6.9
PM_{10}	0.2	0	<0.1	0.2
$PM_{2.5}$	<0.1	0	<0.1	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	<0.1	<0.1
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.

b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.

c. Assumes up to eight launches per year, recovery of up to one payload, and no recovery of new or existing spent stages.

d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Key: NR=not reported; PFRR=Poker Flat Research Range; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

Note: To convert metric tons to tons, multiply by 1.1023.

4.1.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.1.3.1 *Launch Operations*

Under Alternative 1, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

4.1.3.2 *Search and Recovery*

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative because additional search and recovery activities would be undertaken, as described in Appendix F. On average, attempts would be made to recover approximately two payloads and 10 spent stages each year under Alternative 1, as discussed in Appendix F. Emissions from search and recovery operations are presented in **Table 4–5**. These impacts would continue to be regional, adverse, minor and medium-term in duration.

Table 4–5. Alternative 1 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	3.4	24
Nitrogen dioxide	6.9	0	0.13	7.0
PM_{10}	0.2	0	<0.1	0.2
$PM_{2.5}$	0.2	0	<0.1	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	0.2	<0.2
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of up to two payloads, recovery of 10 new spent stages and 5 existing spent stages, and search only for 10 spent stages.
d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Note: To convert metric tons to tons, multiply by 1.1023.

Key: NR=not reported; PFRR=Poker Flat Research Range; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

4.1.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.1.4.1 *Launch Operations*

Annual emissions under Alternative 2 are presented in **Table 4–6**. Under Alternative 2, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative and Alternative 1. Impacts from rocket launches would also be the same as those projected for the No Action Alternative and Alternative 1.

4.1.4.2 *Search and Recovery*

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative or Alternative 1 because additional search and recovery activities would be undertaken, as described in Appendix F. On average, 4 payloads and 16 spent stages would be recovered each year under Alternative 2, as discussed in Appendix F. These impacts would be regional, adverse, minor and medium-term in duration.

Table 4–6. Alternative 2 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon monoxide	15	5.5	4.6	25
Nitrogen dioxide	6.9	0	0.2	7.1
PM_{10}	0.2	0	<0.001	0.2
$PM_{2.5}$	0.2	0	<0.001	0.2
Sulfur dioxide	<0.1	0	<0.1	<0.1
Lead	0	0.2	0	0.2
VOCs	NR	0	0.25	0.25
Hydrogen chloride	0	1.3	0	1.3
Aluminum oxide	0	2.0	0	2.0
Sulfur	0	<0.1	0	<0.1
Copper	0	<0.1	0	<0.1
Other	NR[d]	<0.1	NR[d]	<0.1

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of four payloads, recovery of 16 new spent stages and 10 existing spent stages, and search only for 4 spent stages.
d. Various toxic air pollutants would be emitted from fossil fuel combustion, but these emissions would be small.

Note: To convert metric tons to tons, multiply by 1.1023.

Key: NR=not reported; PM_n=particulate matter with an aerodynamic diameter less than or equal to *n* micrometers; VOCs=volatile organic compounds.

4.1.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

4.1.5.1 *Launch Operations*

Restricted trajectories would not change the projected air quality impacts associated with continued routine operations at PFRR or future launches. Therefore, air quality impacts under Alternative 3 would be the same as those described under Alternative 1 in Section 4.1.3 since Alternatives 1 and 3 would have the same number of future launches.

4.1.5.2 *Search and Recovery*

Restricted trajectories would not change the projected air quality impacts associated with search and recovery activities. Air quality impacts under Alternative 3 would be the same as those described under Alternative 1 in Section 4.1.3 since Alternatives 1 and 3 would have the same number of search and recovery activities.

4.1.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

4.1.6.1 *Launch Operations*

Restricted trajectories would not change the projected air quality impacts associated with continued routine operations at PFRR or future launches. Projected air quality impacts under Alternative 4 would be the same as those described under Alternative 2 in Section 4.1.4 since Alternatives 2 and 4 would have the same number of future launches.

4.1.6.2 *Search and Recovery*

Restricted trajectories would not change the projected air quality impacts associated with search and recovery activities. Projected air quality impacts under Alternative 4 would be the same as those described under Alternative 2 in Section 4.1.4 since Alternatives 2 and 4 would have the same number of search and recovery activities.

4.1.7 Summer Launches

Although it is anticipated that launches and initial search operations would occur during winter months and recovery operations would occur during summer months, there could be summer launches from PFRR, as discussed in Chapter 2, Section 2.1.2.4. With regard to potential air quality impacts, regardless of when the launches occurred, impacts would continue to be global, adverse, minor, and short-term in duration.

4.2 GLOBAL ATMOSPHERE

This section deals with the impact on the Earth's atmosphere of gases, liquids, and solids emitted from rockets and payloads of various NASA SRP launch vehicles during flight. This discussion is extracted or summarized from the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program (SRP SEIS)* **(NASA 2000a)** with appropriate modifications to focus on launches from PFRR. Greenhouse gas emissions are included within this section.

The following definitions and typical altitude ranges are used to describe the Earth's atmosphere **(NASA 2000a)**:

- Lower Atmosphere:
  - Free Troposphere – 2 to 10 kilometers (1.3 to 6.2 miles)
  - Atmospheric Boundary Layer – 0 to 2 kilometers (0 to 1.3 miles)
- Upper Atmosphere:
  - Ionosphere – 80 to 1,000 kilometers (50 to 620 miles)
  - Mesosphere – 50 to 80 kilometers (31 to 50 miles)
  - Stratosphere – 10 to 50 kilometers (6.2 to 31 miles)

4.2.1 Methodology

The exhaust products from rocket launches are estimated by thermodynamic calculation; this is usually performed by computer models or by direct measurement when rocket motors are fired in a stationary location on the ground. In either case, once the relative proportions of each chemical species in the exhaust are known, the rocket's trajectory can then be applied to determine the mass of a particular compound or element that would be emitted at a particular altitude during flight **(NASA 2000a)**. In general, emissions into the atmosphere from sounding rocket launches include halogens (chlorine), particulates (aluminum oxide), carbon monoxide, carbon dioxide, nitrogen oxides, and trace metals **(NASA 2000a)**.

Possible emissions from payloads include exhaust products from any pyrotechnic devices, constituents of batteries, and chemical releases. The impacts of releases from pyrotechnic devices or constituents of batteries are several orders of magnitude smaller than those of chemical releases and are not addressed here **(NASA 2000a)**. Greenhouse gas emissions would be considered moderate if greater than 25,000 metric tons (28,000 tons) of carbon dioxide equivalent direct emissions, the Council on Environmental Quality (CEQ) level above which further analysis is recommended **(Sutley 2010)**. Major impacts could be considered to be several orders of magnitude greater than for a moderate impact. Minor impacts would be any that result in increases of greenhouse gases that are less than the levels specified as moderate impacts, but greater than negligible impacts, which are immeasurable. Major and moderate impacts of ozone-depleting emissions are not readily quantified. For the purpose of this assessment, minor impacts are those that are quantifiable, and negligible emissions are immeasurable.

For the evaluation of duration of atmospheric impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as routine operations at PFRR or the impact from ozone-depleting substances or greenhouse gases that accumulate in the atmosphere.

4.2.2 No Action Alternative

4.2.2.1 *Lower Atmosphere*

At the time of launch, the atmospheric boundary layer (from 0 to 2 kilometers [0 to 1.3 miles]) may or may not be stable and may have an inversion or a strong wind condition. Thus, the initial launch rocket plume may move in an unforeseen direction **(NASA 2000a)**.

The potential environmental impacts in the boundary layer include the following **(NASA 2000a)**:

- Formation of "smog" due to entrainment of atmospheric nitrogen into the exhaust plume, leading to formation of nitric acid and tropospheric ozone;
- Deposition of hydrogen chloride in the boundary layer and subsequent evolution from surfaces near the launch site;
- Disposal and/or deposition of trace heavy metals and organics in the boundary layer, such as lead and sulfur; and
- Diffusion of exhaust particles, such as aluminum oxide, into the boundary layer.

The potential environmental impacts in the free troposphere (from 2 to 10 kilometers [1.3 to 6.2 miles]) include the following **(NASA 2000a)**:

- Formation of high-altitude clouds, which could lead to localized weather modification;
- Adsorption of water-soluble acids such as hydrogen chloride, resulting in localized acid rain; and
- Photochemical oxidation of carbon monoxide to carbon dioxide, and nitrogen oxides to nitric acid and ozone.

The lower atmosphere receives the launch vehicle rocket exhaust emissions from all first stages, plus many second stages in three- and four-stage launch vehicles. The first, or boost, stage usually contains more propellant than the second stage, the second stage more than the third, and so on. Thus, the lower atmosphere receives most of the rocket exhaust emissions from a given launch vehicle (**Figures 4–2** and **4–3**) **(NASA 2000a)**.

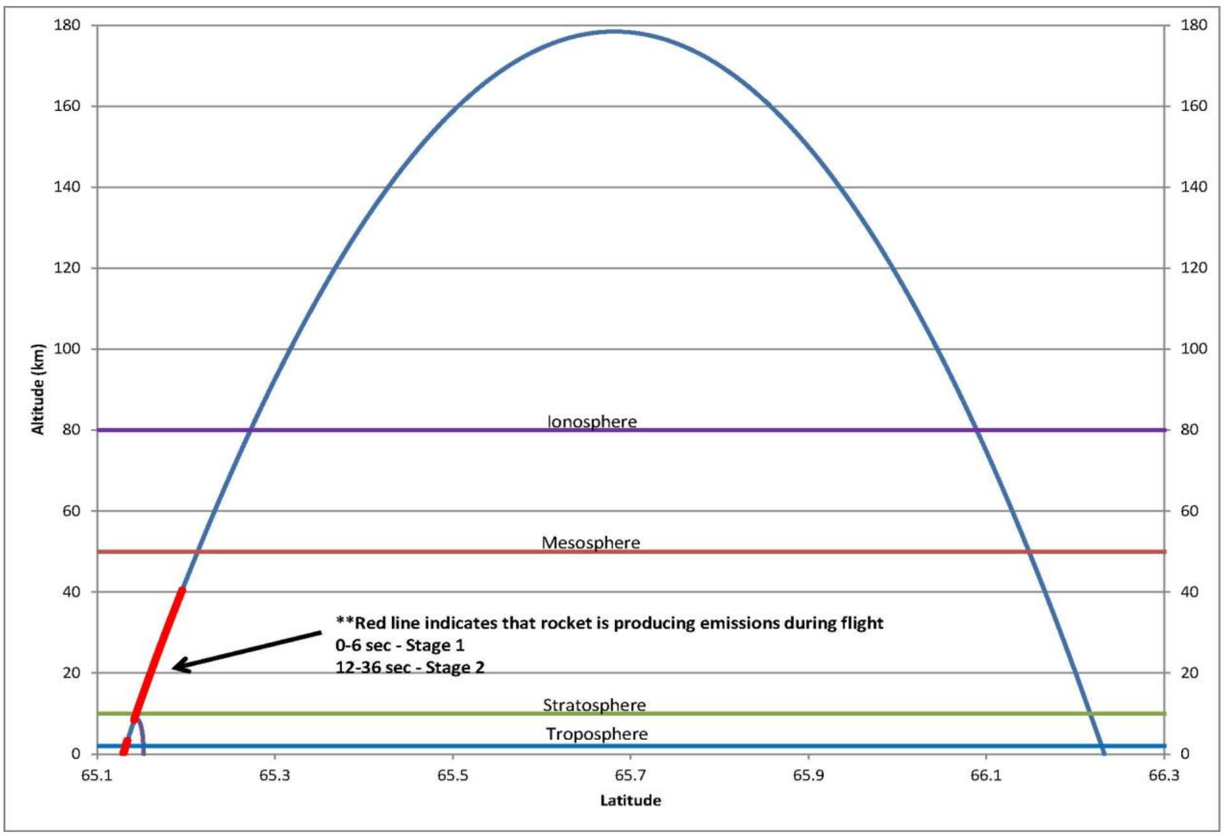


Figure 4–2. Emissions along a Representative Terrier-Improved Orion Trajectory

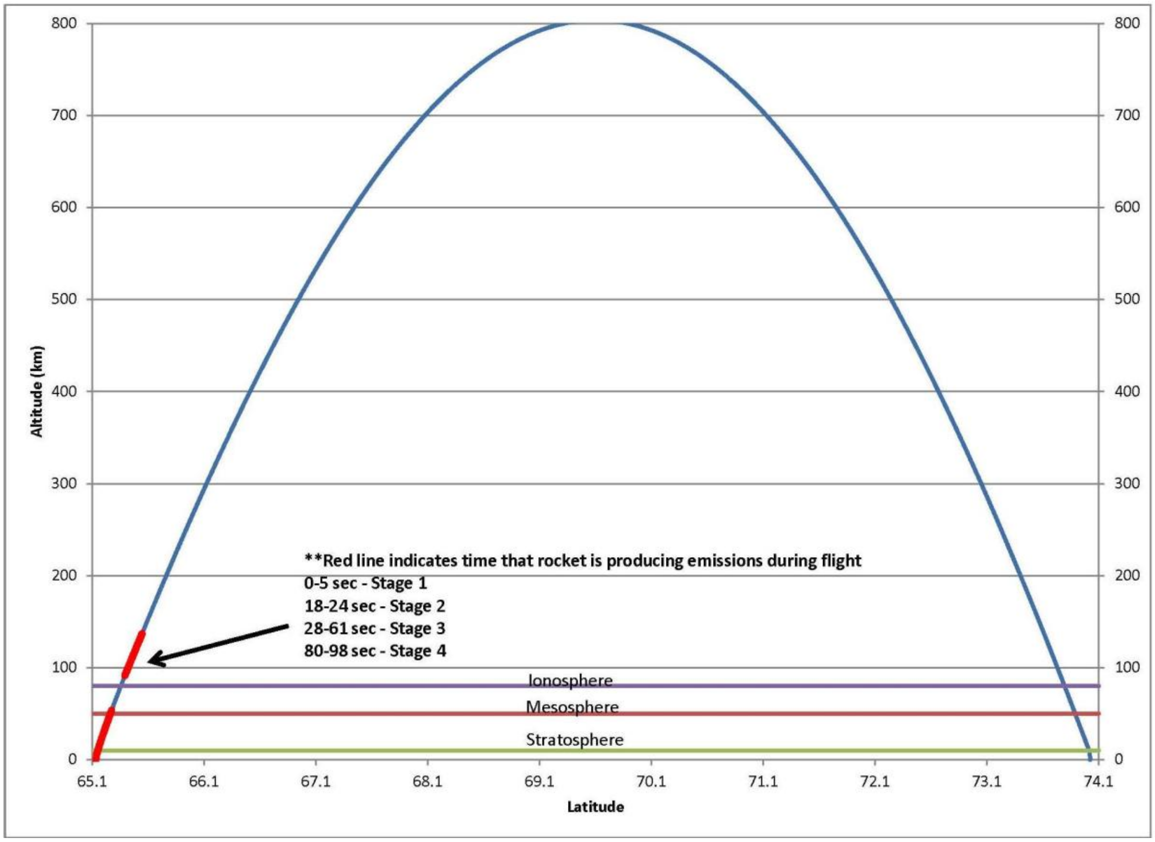


Figure 4–3. Emissions along a Representative Black Brant XII Trajectory

Estimated lower atmosphere exhaust emissions for the two most common launch vehicles used at PFRR are presented in **Table 4–7**. Three criteria pollutants regulated under the National Ambient Air Quality Standards set by the EPA under the CAA are emitted by SRP launch vehicles at low altitudes: lead, carbon monoxide, and particulates (aluminum oxide) **(NASA 2000a)**.

Table 4–7. Poker Flat Research Range Projected Average Annual Lower Atmosphere (<10 kilometers) Rocket Exhaust Emissions (kilograms) for Sounding Rockets

Launch Vehicle	Altitude Range (km)	Hydrogen Chloride	Aluminum Oxide	Carbon Monoxide	Carbon Dioxide	Element	Other	Total
BB XII (1st & 2nd stage [Talos and Taurus] engines)	0–1.9	0	0	3,192	2,576	132 (Lead)	0	5,900
T-IO (1st stage [Terrier] engine)	0–1.5	0	0	912	640	40 (Lead)	0	1,592
Total for up to 8 vehicles	–	0	0	4,104	3,216	172	0	7,492

Key: BB=Black Brant; km=kilometers; T-IO=Terrier-Improved Orion.
Note: Emission represent up to four BB XII launches and four T-IO launches per year. To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Source: NASA 2000a.

Test rockets also emit into the atmospheric boundary layer. Typical lower atmosphere rocket exhaust emissions from test rockets used at PFRR are presented in **Table 4–8**.

Table 4–8. Poker Flat Research Range Projected Average Annual Lower Atmosphere (<10 kilometers) Rocket Exhaust Emissions (kilograms) from Test Rockets

Launch Vehicle	Typical Altitude Range (km)	Carbon Monoxide	Carbon Dioxide	Lead	Methane	Total
70 mm Test Rocket[a]	0–0.6	2.7	1.6	0.039	0.020	4.4
Supporting 4 launches[b]		108	64	1.6	0.8	176
Supporting 8 launches[b]		216	128	3.1	1.6	352

a. Calculations based on two 70-milimeter Test Rockets launched per countdown night.
b. Each sounding rocket launch supported assumed to require 10 nights counting down.
Note: To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.
Source: NASA 2000a.

4.2.2.2 *Upper Atmosphere*

With two-, three- and four-stage launch vehicles, such as the T-IO, BB X, and BB XII, apogees into the ionosphere would be reached. At lower levels of the upper atmosphere (the mesosphere and stratosphere), there are emissions from upper-stage rockets and attitude control system (ACS) fluid jets **(NASA 2000a)**. Some payloads would employ chemical releases to obtain the requisite scientific information; these releases typically take place at the highest altitudes (hundreds of kilometers above the Earth).

Launches

Typical average annual upper-stage rocket exhaust emissions for NASA launch vehicles used at PFRR are presented in **Table 4–9**. Emissions from most of the launch vehicles are confined to the stratosphere. Potential environmental impacts in the upper atmosphere include the following **(NASA 2000a)**:

- Thermal radiation changes due to emissions of water and carbon dioxide and other species into the very thin atmosphere above 50 kilometers (31 miles) in the mesosphere and ionosphere;
- Changes in the ionization level at and above 90 kilometers (56 miles) in the ionosphere, affecting radio wave transmission, due to hydrogen chloride emissions;
- Contribution to global warming due to carbon dioxide emissions (discussed in Section 4.2.2.3 of this EIS); and
- Contribution to depletion of the ozone layer in the stratosphere due to emissions of hydrogen chloride and particulate aluminum oxide, both of which enter into reactions, which can lead to ozone depletion.

Table 4–9. Poker Flat Research Range Projected Average Annual Upper Atmosphere (>10 kilometers) Rocket Exhaust Emissions (kilograms) for Sounding Rockets

Launch Vehicle	Altitude Range (km)	Hydrogen Chloride	Aluminum Oxide	Carbon Monoxide	Carbon Dioxide	Element	Other	Total
Black Brant XII (3rd & 4th stage [Black Brant V and Nihka] engines)	10–153	1,016	1,852	1,416	92	0	24	4,400
Terrier-Improved Orion (2nd stage [Orion] engine)	10–52	256	124	200	176	4 (Cu)	0	760
Total for up to 8 vehicles	–	1,272	1,976	1,616	268	4	24	5,160

Key: Cu=copper; km=kilometers.
Note: Emission represent up to four Black Brant XII launches and four Terrier-Improved Orion launches per year. To convert kilometers to miles, multiply by 0.6214; kilograms to pounds, by 2.2046.

The stratosphere is the main region of ozone production in the Earth's atmosphere. Concentrations vary with the time and place as ozone is continually created and destroyed in complex reactions. The most destructive species leading to stratospheric ozone depletion are believed to be chlorine and bromine. The principal terrestrial sources are industrial chlorinated compounds and emissions from active volcanoes. Rocket emissions directly in the stratosphere are also a contributor **(NASA 2000a)**. Annual stratospheric chlorine releases associated with NASA launches at PFRR are projected to be, at most, about four 10 thousandths of a percent (0.0004 percent) of all industrial sources in the United States, estimated to be approximately 300,000 metric tons (330,000 tons) annually **(NASA 2000a)**. It is expected that there may be a very small, temporary local stratospheric ozone reduction effect in the wake of SRP upper-stage rockets, but no global effects (minor, long-term impacts).For certain observations of deep space phenomena, it is necessary to align optical instruments accurately using an ACS using directed jets of compressed fluids. These jets may use nitrogen, freons, argon, or neon. All of these are permanent gases found naturally in the atmosphere except freons. Freons contain chlorine, which is known to contribute to ozone depletion in the stratosphere. Most of these releases are above 50 kilometers (31 miles), outside the ozone formation zone, and would not create adverse impacts.

Tracer Releases

Historically, tracer releases from sounding rocket payloads at PFRR have been primarily TMA [trimethylaluminum] at altitudes of 80 to 200 kilometers (50 to 120 miles) **(NASA 2000a)**. Quantities of TMA released are typically small, approximately several kilograms. Although it is a liquid at sea level, TMA vaporizes very quickly when released in the low-pressure environment in the upper atmosphere. The TMA reacts spontaneously with oxygen to produce carbon dioxide, water vapor, and aluminum oxide. A byproduct of the reaction is a white light that can be seen from the ground. At ground level, the material burns vigorously because of the high oxygen concentration; however, the reaction is much slower at high altitudes. A complete description of TMA is provided in Chapter 2, Section 2.1.2.2 of this *PFRR EIS*.

Other tracers that have been used in the past (or could be used in the future) are metals. The most common are lithium and barium. To enable these releases, the metal tracer is mixed with thermite in a payload canister vessel. Thermite is a mixture of iron oxide (rust) and aluminum powder. Thermite, when ignited, burns at several thousand degrees and produces enough heat to vaporize the metal tracer. The products of the thermite reaction are iron and aluminum oxide.

Potential environmental effects from high-altitude tracer releases would be minimal. Carbon dioxide and water vapor occur naturally in the atmosphere, although usually not at those altitudes. Aluminum oxide occurs naturally in the upper atmosphere due to deposition by the steady influx of small meteorites that ablate at those heights. The aluminum oxide from the rocket releases is a small fraction of the total aluminum oxide deposited by natural processes. Some of the tracer metals also occur naturally because of meteor ablation, such as lithium, but some, such as barium, do not. All of the releases diffuse rapidly, and the concentrations are quickly reduced.

Other potential impacts of high-altitude tracer releases identified in the *SRP SEIS* **(NASA 2000a)** include visible light emissions that could be observed or that could contaminate non-participating astronomical observations, release of trace amounts of hazardous materials into the biosphere, temporary perturbations of the ionosphere causing temporary disruptions of communications links, modification of trace element concentrations in the upper atmosphere, and contamination of nearby spacecraft by released materials **(NASA 2000a)**.

4.2.2.3 *Climate Change*

Carbon dioxide and other gases in the atmosphere act like glass in a greenhouse, letting the Sun's rays through, but trapping some of the heat that would otherwise be radiated back into space. Emissions of carbon dioxide and other greenhouse gases are believed to affect the Earth's radiative balance and to result in changes in global climate. Activities on Earth are emitting about 26 billion metric tons (29 billion tons) of carbon dioxide per year into the atmosphere (average for 2000–2005) **(IPCC 2007)**. Total U.S. emissions of carbon dioxide are estimated to be 5.45 billion metric tons (6.01 billion tons) per year **(DOE 2011)**. Emissions of carbon dioxide associated with launches, normal operations, and search and recovery activities are presented in **Table 4–10**. Annual emissions of carbon dioxide associated with NASA launches at PFRR, including the continued heating and electrical requirements associated with year-round operation of the PFRR launch site (see Chapter 3, Section 3.1.1), are projected to be, at most, about 4 one hundred thousandths of a percent (0.00004 percent) of total U.S. emissions of carbon dioxide and are not considered substantial. However, scientific uncertainty limits the ability to assess directly attributable effects of greenhouse gases on climate change from selected individual actions. Therefore, NASA provides only a qualitative conclusion concerning these impacts. The No Action Alternative would likely create impacts that increase climate change, which would be global, adverse, minor, and long-term.

Table 4–10. No Action Alternative Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	14	2,120

a. Excludes emissions from rocket launches.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes up to eight launches per year, recovery of up to four payloads, and no recovery of new or existing spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential (**Solomon *et al.* 2007**).

Note: To convert metric tons to tons, multiply by 1.1023.

4.2.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.2.3.1 *Lower Atmosphere*

Impacts from rocket launches under Alternative 1 would be the same as those described under the No Action Alternative.

4.2.3.2 *Upper Atmosphere*

Impacts from rocket launches under Alternative 1 would be the same as those described under the No Action Alternative.

4.2.3.3 *Climate Change*

Launch Operations

Under Alternative 1, air quality impacts from PFRR routine operations would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

Search and Recovery

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative because additional search and recovery activities would be undertaken, as described in Appendix F. Carbon dioxide equivalent emissions from search and recovery operations are presented in **Table 4–11**. Similar to the No Action Alternative, the impact on climate change from the emission of greenhouse gases associated with all of the PFRR activities would be minor and long-term.

Table 4–11. Alternative 1 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	62	2,166

a. Excludes emissions from rocket launches.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes recovery of up to four payloads, recovery of eight new spent stages and six existing spent stages, and search only for 12 spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential (**Solomon et al. 2007**).
Note: To convert metric tons to tons, multiply by 1.1023.

4.2.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.2.4.1 *Lower Atmosphere*

Impacts from rocket launches under Alternative 2 would be the same as those described under the No Action Alternative.

4.2.4.2 *Upper Atmosphere*

Impacts from rocket launches under Alternative 2 would be the same as those described under the No Action Alternative.

4.2.4.3 *Climate Change*

Launch Operations

Annual emissions under Alternative 2 are presented in **Table 4–12**. Under Alternative 2, air quality impacts from PFRR routine activities would be the same as those projected for the No Action Alternative. Impacts from rocket launches would also be the same as those projected for the No Action Alternative.

Search and Recovery

Impacts from search and recovery activities would be larger than those projected for the No Action Alternative or Alternative 1 because additional search and recovery activities would be undertaken, as described in Appendix F. Similar to the No Action Alternative, the impact on climate change from emissions of greenhouse gases from PFRR activities would be long-term.

Table 4–12. Alternative 2 Estimated Annual Poker Flat Research Range Operation, Launch, and Search and Recovery Carbon Dioxide Equivalent Emissions

Pollutant	Emissions (metric tons per year)			
	PFRR Operation[a]	Launches[b]	Search and Recovery[c]	Total
Carbon dioxide (equivalents)[d]	2,100	3.5	100	2,204

a. Excludes emissions from rocket launches. Emissions are from Chapter 3.
b. Assumes up to eight launches per year. Based on emissions from four Black Brant XII launches and four Terrier-Improved Orion launches.
c. Assumes recovery of 4 payloads, and 16 spent stages.
d. Carbon dioxide equivalents include emissions of carbon dioxide and other greenhouse gases multiplied by their global warming potential.

Note: To convert metric tons to tons, multiply by 1.1023.

4.2.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts from the continued operation of PFRR, rocket launches and search and recovery under Alternative 3 would be the same as those described under Alternative 1.

4.2.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts from the continued operation of PFRR, rocket launches and search and recovery under Alternative 4 would be the same as those described under Alternative 2.

4.2.7 Summer Launches

Although it is anticipated that launches and initial search operations would occur during winter months and recovery operations would occur during summer months, there could be summer launches from PFRR, as discussed in Chapter 2, Section 2.1.2.4. With regard to potential global atmosphere impacts, regardless of when the launches occurred, impacts would be global, adverse, minor, and long-term in duration.

4.3 WATER RESOURCES

This section describes potential impacts on surface and groundwater resources as a result of the alternatives.

4.3.1 Methodology

Determination of water resource impacts is based on an analysis of the potential for launch and search and recovery activities to affect surface water or groundwater quality as defined by applicable laws and regulations; wetland disturbance, degradation, or loss; and Wild and Scenic River corridor disturbance. Considered in this analysis is activity-related introduction of contaminants into surface water or groundwater resources; and physical alterations or disturbances of overland surface water flows and groundwater recharge.

Attribute criteria for analyzing potential impacts on surface water and groundwater are presented in **Table 4–13**.

It should be noted that complete National Wetlands Inventory or comparable coverage for PFRR and other adjacent areas of interest—necessary to delineate and analyze potential NASA SRP wetland impacts—were not available. To assess the potential for wetland impacts, analysis was conducted based on PFRR ecoregion surface hydrology and wetland attribute information (see Chapter 3, Section 3.3.4 "Ecoregions").

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Type		
Adverse	The impact would result in some level of impairment, degradation, or disturbance to water resources.	
Beneficial	The impact would result in some level of environmental improvement to water resources.	
Water Quality		
Context		
Global	Effect would have worldwide implications on the quality and/or quantity of water resources.	
Regional	Effect would entail an entire watershed, subbasin, or basin or greater than 50 percent of a major water body.	Effect would entail a surficial aquifer or major aquifer.
Localized	Effect would be limited to the immediate area water body or subwatershed.	Effect would be restricted to the immediate area water table.
Intensity		
Major	Aquatic biology chronic effects such as algae blooms, species mortality, or other comparable consequences or water contamination posing secondary risks would occur.	Effect would prohibit or sharply curtail human potable or nonpotable water uses.

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts (*continued*)

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Water Quality(*continued*)		
Moderate	Noticeable change, aquatic biological response such as species avoidance, or water contamination would occur.	Effect would restrict human potable and nonpotable water uses.
Minor	Effect would be at a low level of detection and have no aquatic biology or contamination risks.	Effect on would be at a low level of detection and have no contamination risks.
Negligible	Effect on aquatic biology and water quality parameters would be imperceptible.	Effect to water quality parameters would be imperceptible.
Duration		
Long-Term	Effect would likely endure for the life of the sounding rocket program or beyond.	
Medium-Term	Effect would likely last for a few months to years.	
Short-Term	Effect would likely last for a few days to weeks.	
Wetlands		
Context		Not Applicable
Global	Effect would have worldwide implications on wetland ecosystems.	
Regional	Effect would entail one or more ecoregions.	
Localized	Effect would be limited to the wetland in the immediate area of the impact source.	
Intensity		
Major	Effect would generate a conflict with Federal and/or state wetland protection programs or violates a Federal or state regulation.	
Moderate	Effect may generate a conflict with Federal and/or state programs but could be mitigated through consultations with regulatory agencies.	
Minor	Effect would be mitigated through consultations with regulatory agencies.	
Negligible	Effect on wetland ecosystem quality and/or quantity would be imperceptible.	
Duration	Wetland impact duration evaluation criteria would be the same as for water quality.	

Table 4–13. Evaluation Criteria for Analyzing Water Resource Impacts (*continued*)

Attribute	Evaluation Criteria	
	Surface Waters	**Groundwater**
Wild and Scenic Rivers		
Context		Not Applicable
Global	Effect would substantially diminish the global protection status of wild and scenic rivers.	
Regional	Effect would entail an entire designated river corridor.	
Localized	Effect would be limited to the portion of the river corridor in immediate vicinity of the impact source.	
Intensity		
Major	Effect would generate a conflict with Federal and/or state wild and scenic river protection programs or violates a Federal or state regulation.	
Moderate	Effect may generate a conflict with federal and/or state programs but could be mitigated through consultations with regulatory agencies.	
Minor	Effect would be mitigated through consultations with regulatory agencies.	
Negligible	Effect on the river corridor would be imperceptible.	
Duration	Wild and scenic river effect duration evaluation criteria would be the same as for water quality.	

4.3.2 No Action Alternative

4.3.2.1 *Surface Water*

Surface water resources of concern include rivers, smaller streams, impoundments (lakes, ponds, sloughs, etc.), lagoons, wetlands, floodplains, coastal zones, and the Beaufort Sea within the PFRR launch corridor. Wild rivers are those federally designated rivers that are managed by the U.S. Department of the Interior (USDOI) to preserve a natural state. Depending on the location, the thickness of frozen surface water within the PFRR flight corridor can range from a few centimeters to several meters during a large portion of the year.

Launch Operations

This analysis focuses on both the potential for exhaust emitted from rocket motors and potential onsite materials handling accidents to affect the quality of stormwater runoff from the PFRR launch site. The primary rocket exhaust byproducts of concern include aluminum oxide particulates and hydrogen chloride gas, which combines with water or water vapor to form hydrochloric acid droplets (see Section 4.2.2.1). These materials would likely settle on the immediate vicinity of the launch pad and snow and/or ice ground cover within tens of meters of the pad. In any one area surrounding the pad, the amounts of exhaust materials would likely be present in small amounts. Since all launches occur in winter, launch residues would likely remain on the pad or snow cover until spring melting; some materials could be transported off site during severe winter storms. It is expected that under normal conditions, rocket exhaust clouds would disperse relatively quickly.

The EPA does not list aluminum oxide as a hazardous material requiring treatment or disposal. At the expected low concentrations, aluminum is a nutrient that could benefit plant growth **(Bohn *et al.* 1979)**. A short-term hydrochloric acid-induced slight decrease in pH (increase in acidity) could occur in small drains or ditches near the launch pad.

Runoff from the PFRR launch site discharges through a series of ditches and drains into the Chatanika River. The launch site does not have or require National Pollutant Discharge Elimination System-permitted stormwater discharge outfalls. The area has limited summer rainfall and relies on natural drainage features to collect and convey runoff to constructed drainage features. Launch site flooding from the Chatanika River spring melt and breakup is rare and normally minor in extent.

The accidental release of hazardous materials such as fuels, oils, lubricants, batteries, alcohols, and acetone during rocket launch preparation could also impact water quality. However, pre-flight preparations would take place within existing facilities and precautions are taken to prevent and control spills. PFRR maintains strict adherence with applicable Hazardous Materials Transportation Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, and Hazardous and Solid Waste Act regulations and requirements to prevent and control accidental spills. The potential for rocket propellant or other materials to be accidentally released during flight is considered remote; however, PFRR emergency response personnel would mitigate the impact of any spill.

In summary, given the small number of annual sounding rocket launches planned for PFRR, the low quantities of aluminum oxide and hydrochloric acid exhaust residues, and low risk of accidental spills, it is anticipated that the potential adverse impacts on surface water quality would be localized in context, negligible in intensity, and short-term in duration.

Flight Hardware

This evaluation focuses on the potential for hardware from both normal and failed flights to impact water quality or affect protected waters. Specific issues to be analyzed include the potential for metals, pollutants, payload batteries and other materials to impair water quality in general, as well as the specific characteristics of federally designated wild river segments.

Normal Flights – It is assumed that in most cases, normal flight hardware landing in layers of snow and ice would likely not penetrate the frozen soil or would enter the soil to a depth of less than 0.6 meters (2 feet). Impacts with rocky materials and thick ice could minimize penetration depth, whereas areas with underlying wetland soils may present reduced resistance, particularly in the early or later months of the launch season (*e.g.*, October or April). The weight, velocity, and orientation of the falling flight hardware would also affect penetration depth. Similarly, intact stages and payloads directly impacting frozen water bodies could come to rest on the surface or could penetrate the ice.

In most cases, flight hardware would not be exposed to fluid aquatic environments until spring melt, except for spring-fed stream segments in the Arctic Coastal Plain, Arctic Foothills, and Brooks Range Ecoregions that may continue to flow during winter (see Chapter 3, Section 3.3.4, "Ecoregions"). The dynamic nature of Beaufort Sea ice breakup and deforming (see Section 3.3.4.1, "Beaufort Sea Ecoregion") and river ice-jams during spring and summer could also affect the physical integrity and distribution of hardware.

Steel, magnesium, and aluminum components that enter freshwater or marine environments have the potential to corrode and introduce metal ions to the water column. During wet corrosion, the metal electrons combine with atoms of oxygen and water to make a new hydroxyl ion that reacts to make a stable compound with the metal ions. These new compounds are either deposited loosely on the metal item's surface or away from it, thus providing little protection from continued corrosion. Once corrosion starts, it continues until the ingredients are exhausted. It is estimated that even under long-term interment within the water column, toxic concentrations of metal ions would not be produced because of the slow rates of corrosion and mixing and dilution characteristics of most freshwater and marine environments.

Expended rocket stages may also contain trace amounts of solid propellant not burned during normal flights. Solid propellant dissolves slowly, and the small amounts that would likely occur would dissipate within hours or days in freshwater and marine ecosystems. Potential effects would likely be most pronounced in close proximity of the propellant and in small (0.05-hectare [0.1-acre] or less), shallow ponds and sloughs. Of the ecoregions within the PFRR launch corridor, Yukon Flats likely has the highest overall density of these water features. However, considering the limited number of stages expended over the PFRR launch corridor, dilution and dispersion effects of freshwater and marine environments, potential biological immobilization and degradation, and the minor amount of materials likely involved, very minor, localized impacts on surface water features are anticipated.

Payloads may contain battery electrolytes, hydraulic fluids, and other materials that could affect water quality. Silver zinc and nickel cadmium are common types of power systems **(NASA 2001)**. The types, quantities, and combinations of these payload materials can vary with each flight experiment and are discussed in detail in Section 4.12, Waste Management. These materials occur in relatively small quantities for most sounding rocket payloads and may be recovered. In the case of flights that terminate accidentally, recovery teams attempt to recover all on- and offsite fragments. Based on the relatively low number of flights, small payload quantities, and established recovery procedures in the event of a failure, negligible impacts on the quality of surface water features, including wetlands and coastal zones, are anticipated.

Failed Flights – The most likely causes leading to a sounding rocket failure would be non-ignition of a motor during ascent followed by burn-through of the rocket motor casing. Should a motor fail to ignite, the vehicle would fall to Earth and explode on ground impact, producing fragmented metal and small amounts of unspent propellant. Should a rocket motor experience burn-through, it would most likely expend its propellant prior to landing. Depending on which stage the failure were to occur, upper stages would not ignite and would detonate upon landing. This type of malfunction, although possible, would be rare and likely have an occurrence probability of approximately two percent based on past NASA experience **(Hickman 2012)**. Should such a failure occur, a PFRR recovery team would, to the degree possible, locate and retrieve all components of the rocket.

It is estimated that a rocket vehicle explosion on non-wetland areas could create a crater estimated to be as large as 6 meters (20 feet) in diameter, up to 3 meters (10 feet) deep, with an area of 28 square meters (304 square feet). The surface snow, ice, and frozen surface soils in the immediate area would partly melt. The greater the depth of the snow or ice or the harder the surface impacted, the lower the amount of land that would be disturbed. During the spring melt process, runoff could result in soil erosion. The extent of soil detachment and transport by runoff could range from minor sheet erosion to the development of a gully system that may contribute amounts of sediment. The mechanics of soil erosion for a site would be highly variable and primarily depend on the volume, velocity, and duration of surface runoff, soil morphology, vegetative cover, and topography. An example of what would be considered a worst-case failed flight scenario is shown below in **Figure 4–4**, which depicts the impact site of a Black Brant V motor (the third stage of a Black Brant XII launch vehicle) that failed to ignite in March 2005. However, other failed flights, such as that of the March 2003 Terrier-Improved Orion depicted below in **Figure 4–5**, would be expected to have little, if any physically induced disturbances to water resources.

Water resource exposure to unspent quantities of rocket propellant may occur following a flight failure. It is assumed that most of the propellant would explode upon impact of the failed payloads or stages and any remaining residual composite-base solid propellant would be fragmented into smaller pieces averaging less than 2 kilograms (5 pounds). The chemical material of particular concern would be aluminum perchlorate, which typically composes 50 to 85 percent by weight of the propellant.

Figure 4–4. Impact Site of Non-Ignited Black Brant V from March 2005

Figure 4–5. Impact Site of Failed Terrier-Improved Orion from March 2003

A laboratory study conducted by **Lang *et al.* (2003)** investigated the rates for perchlorate release from composite-base propellants immersed in water as affected by salinity (deionized water and salt-water solutions) and temperature. Samples were studied at temperatures ranging from 5, 20, and 29 degrees Celsius (°C) (41, 68, and 84 degrees Fahrenheit [°F]). The results showed a direct correlation between increased rates of perchlorate release with increasing temperature, higher release rates in pure water than in salt water, and larger immersed samples. The diffusion[2] coefficients for tested propellants ranged from of 1.1×10^{-13} to 3.6×10^{-12} square meters per second (1.2×10^{-12} to 3.9×10^{-11} square feet per second). The estimated time for a propellant sample to lose 90 percent of its mass to leaching is presented in **Table 4–14**.

Table 4–14. Estimated Time to Reach 90 Percent Mass Loss of Perchlorate from Propellant Sample

Water Type	Water Temperature Celsius (Fahrenheit)	Days	Years
Deionized Water	29 (84)	200	0.5
	20 (68)	330	0.9
	5 (41)	3,800	11.0
Salt Water	29 (84)	270	0.7
	20 (68)	540	1.5
	5 (41)	6,700	18.0

Source: Lang *et al.* 2003.

[2] Diffusion is the process whereby material is transported by the random movements of molecules. There is an average measurable movement of areas of high to low areas of concentration **(Lang *et al.* 2003)**.

Based on the lowest average temperature of 5 °C (41 °F)[3] shown in Table 4–14, it would take approximately 11 to 18 years for 90 percent of perchlorate to leach from propellant immersed in freshwater and marine ecosystems, respectively.

Based on the low probability of a flight terminating and producing unspent propellant, dynamic hydrologic dispersion and dilution effects of wave action and ocean currents, large volume of water available for dilution, and expected slow rate of perchlorate release, no impacts on Beaufort Sea water quality are anticipated. For freshwater ecosystems, potential impacts could occur, particularly in small (less than 0.1-hectare [0.2-acre]), shallow ponds and sloughs. At the expected low concentrations, ammonium is a plant nutrient that could stimulate plant growth for short periods. Perchlorate ions tend to react (oxidize) with organic matter that is common to many wetlands and pond ecosystems within the PFRR launch corridor. Potential adverse water quality impacts would be localized in context, minor in intensity, and short-term in duration.

Wild Rivers – Four federally designated Wild River segments occur partly or wholly with the PFRR launch corridor (see Chapter 3, Section 3.3.2, Table 3–8 "Poker Flat Research Range National Wild and Scenic River Segments"). It is possible for flight hardware from normal flights and flights that malfunction to land within these river segments. From a purely biological or chemical perspective, if flight hardware were to land within a designated river, the effects would be the same as equivalent non-designated water bodies; however, given their special designation, additional socio-cultural effects could occur. These potential effects are discussed in this *PFRR EIS* in Section 4.8, Land Use and Recreation.

The potential for sounding rocket hardware to land within wild river segments was calculated (see Appendix G). Potential impact areas would include the designated Wild river channel and adjacent land areas. For a typical launch from PFRR, the potential for flight hardware impacts on the Beaver Creek, Ivishak River, and Wind River designated wild river segments is estimated to be 6, 4, and up to 5 percent, respectively (see Appendix G, Table G–2). Potential impact ellipses range in size from 2,600 to 28,400 square kilometers (1,000 to 11,000 square miles). Based on these low relative probabilities, it is estimated that the potential for flight hardware from a typical launch to land within the designated Wild River corridors is remote; therefore, impacts are anticipated to be negligible. Additional information on flight hardware impact probabilities is discussed in Section 4.15.9, Cumulative Effects, and Appendix G.

Search and Recovery

Payload recovery operations (*e.g.,* hand-digging buried items) have the potential to disturb surface soils, which in turn could result in sediment-laden runoff entering nearby waterways during storm events. However, those payloads planned for recovery would employ recovery systems (parachutes), which would substantially reduce the potential for burial. Accordingly, the extent of potential disturbance would be minor in intensity, localized in extent, and short-term in duration.

[3] Average water temperatures in the Beaufort Sea are estimated to be approximately 0 °C (32 °F) **(Encyclopedia Britannica 2011)** and average water temperatures in Arctic National Wildlife Refuge (NWR) are also expected to be low due to melting snow and ice.

Should a helicopter or airplane accident occur during search or recovery operations, there is the potential for fuselage metal debris, fuel, and other materials to land in surface water and affect water quality. Impacts would primarily be associated with the release of fuels and hydraulic fluids. The cleanup of reportable quantities of hazardous materials is also required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) **(42 U.S.C. 9601 *et seq.*)**. Since the probability of an accident is remote and it is anticipated that spills would be cleaned up to CERCLA standards, no environmental impacts on surface waters from search and recovery activities were identified.

4.3.2.2 *Groundwater*

Subsurface water features of concern include near-surface groundwater associated with perched and permafrost talik layer (see Chapter 3, Section 3.4.1, "Permafrost"), water tables, and perennial springs. Near-surface water tables a few centimeters to 1 meter (3.3 feet) below the surface are common to the Arctic Coastal Plain and ecoregions south of Brooks Range. These systems interact directly with surface water features. Even during the coldest winters, some groundwater continues to flow beneath much of the PFRR launch corridor.

Launch Operations

Although there is a potential for spills of hazardous materials during flight preparation activities and deposition of low amounts of rocket exhaust residues on the surface to affect water tables, no groundwater impact pathways were identified. No perennial springs were identified in the vicinity of the PFRR launch site. Accordingly, it is anticipated that the impacts on the PFRR launch site water table or perennial spring water quality would be negligible.

Flight Hardware

Normal and failed flights would produce hardware that would reside on the surface or could penetrate the soil during winter. Potential exposure of near-surface groundwater to metal ions, perchlorate propellant residues, battery electrolytes, or hydraulic fluids from the limited number of NASA SRP launches from PFRR would be localized and likely at trace-level concentrations. Failed rocket impacts and surface detonation could cause an immediate disturbance of near-surface groundwater environments, but overall effects would be considered negligible. Impacts on water table or perennial spring water quality or recharge are anticipated to be negligible.

Search and Recovery

Search and recovery activities could occur in areas with near-surface groundwater and perennial springs. Operational impacts on groundwater features would be associated with an unintended fuel or hydraulic fluid spill by a helicopter at the recovery site during debris item extraction. Fluid spills could also occur from fixed-wing aircraft or helicopter accidents during search and recovery operations. These impact scenarios would rarely occur within the PFRR launch corridor, and individual events would be isolated and limited in extent. The limited number of search and recovery operations under the No Action Alternative would also reduce the probability of adverse impacts. Therefore, impacts on groundwater resources are anticipated to be negligible.

4.3.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Additional efforts would be made to locate and recover historic spent stages and payloads and recover, to the extent practicable, newly expended rocket stages in an environmentally sensitive and safe manner. Accordingly, additional recovery-related surface disturbance would occur, potentially increasing the potential for sediment-laden runoff to enter surface waters. The risk of spills from recovery equipment would also increase; however, the additional impacts on surface water or groundwater resources beyond those discussed for the No Action Alternative in Section 4.3.2 would be minor. NASA would ensure that recovery crews minimize and mitigate any site damage incurred during recovery.

4.3.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Maximum practical efforts would be made to locate and recover historic spent stages and payloads and recover, to the degree possible, newly expended rocket stages. During search and recovery operations, there would be the potential for impacts that are minor in magnitude and short-term in duration. Actions would be taken to minimize and mitigate any site damage incurred during recovery; however, a more frequent and aggressive recovery program could result in the greatest potential for impacts on surface waters through land disturbance during removal, as well as risk of fuel spills.

4.3.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on surface water and groundwater quality under Alternative 3 would be similar to those identified under Alternative 1 in Section 4.3.3, with the exception of NASA's restricting trajectories on future launches such that designated wild river segments would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the already low probabilities that spent stages or payloads would land within designated Wild and Scenic River segments within PFRR.

4.3.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on surface water and groundwater quality under Alternative 4 would be similar to those identified under Alternative 2 in Section 4.3.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or proposed Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the already low probabilities that spent stages or payloads would land within designated Wild and Scenic River segments within PFRR.

4.3.7 Summer Launches

There is a possibility that a rocket experiment could be launched from PFRR during the summer. Compared to winter conditions, interaction of flight hardware with surface water or groundwater resources would be more immediate. However, the principles and patterns of possible water resource impacts would follow similar trends and ultimate endpoints, as discussed in the previous subsections related to surface water and groundwater impacts. No further precautions would be required related to potential surface water and groundwater impacts should a summer launch be planned from PFRR.

4.4 GEOLOGY AND SOILS

This section describes potential impacts on geology and soil resources in and around PFRR and under the launch corridor as a result of the alternatives.

4.4.1 Methodology

The project alternatives do not include construction or significant surface alteration activities that would expose or disrupt geologic formations or impact glaciers, cause slope mass wasting and debris avalanches, or induce seismic activity. Further analysis of potential consequences to geologic features is subsequently excluded from this section. However, there is the potential for soil impacts, including soil damage and soil erosion.

The determination of soil impacts is based on an analysis of the potential for PFRR alternative rocket launch and search and recovery activities to alter the physical or chemical properties of soil or increase the potential for soil erosion. Criteria for evaluating potential impacts on soil resources are presented in **Table 4–15**.

Table 4–15. Evaluation Criteria for Analyzing Soils Impacts

Attribute	Evaluation Criteria
Type	
Adverse	The impact would result in some level of impairment, degradation, or disturbance to soil resources.
Beneficial	The impact would result in some level of environmental improvement to soil resources.
Attribute	**Soil Chemistry**
Context	
Global	Effect would have worldwide implications on the quality of soil resources.
Regional	Effect would be transported by runoff or stream flow throughout the watershed, subbasin, or basin.
Localized	Effect would be isolated to the area affected by the disturbance source.
Intensity	
Major	Effect would generate a substantial change in multiple soil chemistry parameters and result in the eradication of one or more naturally occurring soil organisms.
Moderate	Effect would create a noticeable change in one or more soil chemistry parameters and result in discernible declines in naturally occurring soil organisms.
Minor	Effect on soil chemistry and/or soil organisms would be at a low level of detection and present no contamination risks; effect could be mitigated by onsite personnel or consultations with regulatory agencies.
Negligible	Effect on soil chemistry and/or soil organisms would be at the lowest level of detection or imperceptible.

Table 4–15. Evaluation Criteria for Analyzing Soils Impacts (*continued*)

Attribute	Soil Chemistry (*continued*)
Duration	
Long-Term	Effect on soil chemistry beyond natural thresholds and/or declines in soil organisms would persist for the duration of the program or beyond.
Medium-Term	Effect on soil chemistry and/or soil organisms would stabilize within a few months to years.
Short-Term	Effect on soil chemistry and/or soil organisms would stabilize within a few days to months.
Attribute	**Soil Erosion**
Context	
Global	Effect would have worldwide implications on the quality and/or quantity of soil resources.
Regional	Sediment generated by the disturbance source rill and/or gully erosion features is discharged off site onto adjacent land areas, water bodies, and/or watershed streams.
Localized	Sediment generated by sheet and/or rill erosion features remains on site in close proximity to the disturbance source and is not discharged into water resources.
Intensity	
Major	Impact site disturbances are extensive and prominent gully features deliver substantial amounts of sediment off site that may smother terrestrial vegetation or is discharged into water resources; a violation of the Clean Water Act.
Moderate	Impact site exhibits prominent area of bare ground and rill and/or gully features are present; generated sediment primarily remains on site.
Minor	Impact site exhibits physical soil disturbances and soil sheet and/or rill features are present but would quickly stabilize or be mitigated by onsite personnel or consultations with regulatory agencies.
Negligible	Impact site exhibits small areas of ground disturbance and the effects of erosion are imperceptible; no distinguishable erosion features would form.
Duration	
Long-Term	Effect of gully soil erosion features would persist for the duration of the program or beyond.
Medium-Term	Effect of rill and/or gully soil erosion features would stabilize within months to years.
Short-Term	Effect of sheet and/or rill soil erosion features would stabilize within weeks to months.

4.4.2 No Action Alternative

Activity-induced soil erosion and sediment generation and offsite delivery can damage and destabilize soils, impact water quality, and alter localized area biological productivity. The Gelisol soil order, which is dominant within the Arctic Coastal Plain, Arctic Foothills, and Brooks Range Ecoregions, is particularly sensitive to surface disturbance, and impacts are often long-term and irreversible (see Chapter 3, Section 3.4.5 “Ecoregions”). Disruption of surface soils that alters the seasonal patterns and properties of thawing and freezing could adversely affect permafrost integrity. The sandy soil texture that characterizes many soil series in the Entisol soil order that frequently occupies portions of stream and river floodplains and sandy to silty soil texture of soil series in the Incepitosol soil order may be particularly susceptible to runoff-induced soil erosion and sedimentation (Section 3.4.4, “Soil Orders,” and Table 3–11, “Poker Flat Research Range Soil Orders”). Entisols and Incepitosols are common to the Interior

Forested Lowlands and Uplands, Interior Highlands, and Yukon Flats Ecoregions (see Chapter 3, Section 3.4.5).

4.4.2.1 *Launch Operations*

This analysis focuses on the potential impacts of rocket launches and accidental spills of chemical materials during launch preparations on PFRR launch pad area soil chemistry and soil erosion. During launches, the rocket composite-base motors would deposit aluminum oxide particulates and hydrogen acid droplets created when hydrogen chloride gas combines with water or water vapor. These materials could come into contact with soils not covered with snow in the immediate launch area.

The ground concentration of aluminum oxide and hydrogen acid per launch event is anticipated to be small, and deposition of measurable levels from moving exhaust clouds would likely be negligible. Hydrogen acid droplets would be dispersed in the exhaust cloud and would likely not reach concentrations that would affect soil pH. However, aluminum oxide has the potential for long-term residence in the soil environment, which could affect soil chemistry. It is estimated that expended aluminum oxide particulates would be confined to the immediate soil area and would remain within a few centimeters of where they first contacted the soil because of the strong retention characteristics of inorganic and organic components, plant uptake and decay, and other mechanisms. Once released, metal molecules become mobile or immobile in the soil, depending on the site characteristics of the soil, vegetation, hydrology, and climate. Aluminum is a plant nutrient that may be sequestered by plants near the launch pads **(Bohn *et al.* 1979; McLean and Bledsoe 1992)**. It is expected that over multiple launches, aluminum oxide and hydrogen chloride in the soil would remain at non-critical levels. Additional soil disturbance could increase the mobility and availability of aluminum, as well as its susceptibility to offsite transport.

Pre-flight preparation could result in accidental spills of hazardous materials such as fuels, oils, lubricants, batteries, alcohols, and acetone during rocket launch preparation, which in turn could affect soil chemistry. However, nearly all pre-launch activities involving such substances are performed within shelters or buildings, further reducing the potential for a release. PFRR maintains strict adherence with applicable Hazardous Materials Transportation Act, Toxic Substances Control Act, Resource Conservation and Recovery Act, and Hazardous and Solid Waste Act regulations and requirements to prevent and control accidental spills.

In summary, it is anticipated that the potential impacts on soils associated with the limited number of annual sounding rocket launches (an average of four per year), low quantities of aluminum oxide and hydrochloric acid residues, and low probability of accidental spills at PFRR would be localized in context, negligible in intensity, and short-term in duration.

4.4.2.2 *Flight Hardware*

This evaluation focuses on the potential for flight hardware from normal flights and failed flights to impact PFRR launch site and launch corridor soil environments. Specific issues to be analyzed include the potential for fallen hardware to affect soil disturbance and erosion and for metals, propellants, payload batteries, and other materials to impact soil chemistry.

Normal Flights – For normal flights, a rocket stage returning to Earth at ballistic velocities could disturb and displace soil materials on impact. However, since all launches would be conducted during winter, when the surface is covered in snow and ice, the potential damage to the surface would be significantly reduced. It is anticipated that most flight hardware would not impact the ground surface but would remain in the ice or snow until the area thaws, and the items that do impact the ground surface would result in minor secondary soil disturbance. Under winter snow and ice cover and frozen soil conditions, no soil erosion impacts or degradation of permafrost from flight hardware is expected.

Rocket steel, magnesium, and aluminum components that reenter and land on the ground could corrode and introduce metal ions to the soil environment. During dry corrosion, metal atoms and oxygen combine to produce a protective surface layer of converted metal (oxide) that does not react with oxygen in the air or the metal. Eventually, the layer of oxide grows so thick that the movement of electrons and ions that fuels the corrosion process stops. Provided the layer of oxide is thick enough and not cracked or perforated, the metal is protected from further corrosion. However, the protective layer may crack and spall due to the differences in the thermal expansion coefficients between the corrosion products and the metal. Dry corrosion is primarily regulated by climate and soil chemistry and ranges from a few years to hundreds of years **(USEPA 2001**, **2002; Rashidi *et al.* 2007)**. In most cases, metal ions introduced to the soil surface tend to be relatively immobile or move slowly through the soil profile **(McLean and Bledsoe 1992)**. The relatively low rainfall and cooler climate of PFRR reduce metal corrosion rates compared to warmer, wetter climates. As such, no measurable impacts on PFRR launch site or launch corridor soil chemistry are anticipated from the corrosion of metal debris.

Expended rocket stages may also contain trace amounts of solid propellant, and vehicle payloads may contain battery electrolytes, hydraulic fluids, and other toxic materials that could affect soil chemistry. Perchlorate in the soil at levels of about 100 to 1,000 milligrams per liter (100 to 1,000 parts per million) could decrease soil respiration, which may adversely affect nutrient cycling and plant growth. However, the levels of perchlorate in the soil associated with normal flights are expected to be well below 100 milligrams per liter (100 parts per million). The buffering capacity of soils with substantial amounts of organic matter would further diminish potential effects on soil chemistry **(Federer and Hornbeck 1985)**. Based on the relatively low number of flights, small payload quantities, relatively small ground area that would be affected, low levels and decomposition rates of perchlorate in the soil, and recovery procedures as outlined in Section 4.3.2.1, adverse impacts on soil chemistry would be short-term, negligible, and localized.

Failed Flights – Failed rockets that fall to the Earth and explode on impact could affect surface soil physical and chemical environments. It is estimated that a rocket vehicle explosion on non-wetland areas could create a crater estimated to be up to 6 meters (20 feet) in diameter, up to 3 meters (10 feet) deep, with an area of 28 square meters (304 square feet). The surface snow, ice, and frozen surface soils in the immediate area would partly melt. During the spring melt process, runoff could result in disturbance area site soil erosion and subsequent offsite sediment delivery. Sediment generation and delivery are discussed in Section 4.3.2.1. Most of the propellant would be consumed at impact or in secondary burn-offs of dispersed material. In summary, potential adverse impacts on soil erosion would be possible, minor in intensity and medium-term in duration. Short-term, localized, negligible adverse impacts on soil chemistry are anticipated.

4.4.2.3 *Search and Recovery*

Under the No Action Alternative, expended payloads would only be recovered if desirable for scientific or programmatic needs. No impacts on soil resources associated with the transfer of materials from helicopter to fixed-wing aircraft for ultimate delivery to the PFRR launch site are anticipated.

Recovery operations have the potential to disturb surface soils; however, the effects are expected to be negligible. Since off-road vehicles (*i.e.*, snow machines) would only be used in response to an off-nominal flight that would have landed immediately downrange from the launch site, soil compaction and rutting damage would not be expected. Snow at depths greater than 25 centimeters (10 inches) has been found to measurably reduce potential subsurface disturbances from much larger off-road vehicles **(Felix and Raynolds 1989)**, and given that a snow-machine-based response would not likely entail many passes over the same trail, any effects would be negligible. It is possible that small quantities of fuels or lubricants could be deposited along regularly used trails **(Ingersoll 1999)**; however, the limited use of these vehicles would not result in measurable impacts on soils. Should a helicopter or airplane accident occur during search or recovery operations, there is the potential for fuselage metal debris, fuel, and other materials to affect soils. However, based on previous analysis, negligible adverse impacts on soil chemistry are anticipated and adverse impacts on soil erosion would be minor in magnitude and medium-term in duration.

4.4.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Additional efforts would be made to locate and recover historic spent stages and payloads and recover, to the extent practicable, newly expended rocket stages in an environmentally sensitive and safe manner. Therefore, potential impacts beyond those discussed for the No Action Alternative would be minor.

4.4.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the number of anticipated rocket launches at PFRR would remain the same as the No Action Alternative. Maximum practical efforts would be made to locate and recover historic spent stages and payloads and recover newly expended rocket stages. During recovery operations, there would be the potential for isolated impacts that are minor in magnitude and short-term in duration. Actions would be taken to minimize and mitigate any site damage incurred during recovery. No additional impacts on soils beyond those discussed for the No Action Alternative in Section 4.4.2 are anticipated.

4.4.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on soils under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be permitted to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on soils within PFRR.

4.4.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on soils under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.4.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on soils within PFRR.

4.4.7 Summer Launches

Compared to winter conditions, interaction of rocket stages with soil resources would be more immediate because there would not be as much snow and ice on the surface to cushion the impact of spent stages or payloads. However, the principles and patterns of possible soil-related impacts would follow the same trends and ultimate endpoints, as discussed in the previous subsections, and no substantial direct impacts on soils are expected to result from summer launches. Indirect impacts could result from the increased likelihood of a wildfire starting as a result of a spent stage igniting such a fire. Under such circumstances, before a summer launch was conducted, additional precautions would be taken to minimize the risks associated with igniting such a fire, including notifying appropriate fire patrol personnel.

4.5 NOISE

This section describes potential impacts that would result from noise generated by the alternatives. The primary focus of this section is to characterize the noise levels that would occur. The potential effects of the noise on receptors (*e.g.,* wildlife, recreational users) are discussed within each resource's respective section.

4.5.1 Methodology

Noise impacts could result from routine PFRR activities, employee vehicles, delivery vehicles, rocket launches, and search and recovery activities. Noise from ongoing routine activities at PFRR is evaluated qualitatively. Noise from sounding rockets and search and recovery aircraft is provided in a quantitative format.

Estimation of Rocket Noise

NASA estimated rocket noise levels using a simple methodology that considers several of the primary performance factors of a rocket. The overall sound power of a rocket is taken to be one-half percent of its mechanical power; mechanical power is simply half the product of the rocket thrust and the gas velocity at the rocket nozzle exit plane. The gas exit velocity does not vary too much for different rockets, so it is the *thrust* that mainly determines the sound power. When these parameters are known, a source level calculation can be made.

Noise impacts from the BB XII and T-IO launch vehicles are presented as they are expected to generate the highest noise levels of the launch vehicles planned for future use at PFRR. Although other launch vehicles may be used at PFRR, their associated noise levels are expected to be less than or equal to the BB XII and T-IO. Much of the discussion regarding rocket noise is adapted from the *SRP SEIS* **(NASA 2000a)**, with appropriate modifications to focus on launches from PFRR.

An additional quantitative analysis that was not performed for the *SRP SEIS* **(NASA 2000a)**, but is included in this section, is the characterization of potential sonic booms felt on the ground during flight. For this analysis, NASA employed the PCBoom4 computer model **(Plotkin and Grandi 2002)**.

Estimation of Aircraft Noise

Aircraft noise levels from search and recovery activities were calculated using the Federal Aviation Administration's INM [Integrated Noise Model] **(FAA 2008)**. Each search and recovery operation would warrant specific consideration, and accordingly, a variety of craft could be flown. The specific vehicles that were chosen for this EIS are representative of the class of aircraft that would be employed by PFRR during such efforts. Other aircraft may be used by PFRR; however, noise levels would not be expected to deviate substantially from those evaluated.

An important consideration when assessing sound generated by aircraft is *slant distance*, which is a combination of aircraft height above ground level (AGL) and the horizontal distance from the receptor to an aircraft not directly overhead. A National Park Service study **(Anderson and Horonjeff 1992)** described the relationship between increasing altitude or slant distances and diminution of sound levels. Very large reductions in sound levels (on the order of 15 to 25 decibels [dB]) are experienced as altitude or slant distance increases from 38 to 305 meters (125 to 1,000 feet). Increases from 305 to 610 meters (1,000 to 2,000 feet) in altitude would produce smaller, but still moderate to substantial, reductions (on the order of 4 to 8 dB). Between 610 and 2,133 meters (2,000 and 7,000 feet) AGL, 305-meter (1,000-foot) increases in distance produce considerably smaller reductions in sound levels (on the order of 3 to 5 dB) and above 2,133 meters (7,000 feet) AGL, each 305-meter (1,000-foot) increase in altitude results in only very small reductions in sound level **(Anderson and Horonjeff 1992)**.

Classification of Impacts

For the evaluation of magnitude of noise impacts, major impacts would be any that result in noise levels that interfere with long-term use of nearby properties or displacement of wildlife in wilderness or wildlife refuge areas (see Section 4.7). Moderate impacts would be those that result in temporary interference with intended uses of nearby properties, temporary startle of wildlife, or temporary interference with the natural experience of visitors to a wilderness, wildlife refuge, or recreation area, such as from the low-level overflight of a search plane or helicopter. Minor impacts would be those that result in measurable noise levels but do not normally interfere with activities, result in startle of wildlife, or normally interfere with the natural experience of visitors to a wilderness, wildlife refuge, or recreation area, such as from employee traffic. Negligible impacts would be those that are immeasurable.

For the evaluation of duration of noise impacts, short-term impacts would be any that occur for brief periods that are much less than the total project life, such as from rocket launches, which typically only produce first-stage noise for a few seconds and overall launch noise for a minute or two. Medium-term impacts would be any that occur for relatively brief periods less than the total project life but may occur repeatedly, such as from search and recovery operations. Long-term impacts would be any that occur for periods longer than medium-term and as long as the life of the project or longer, such as routine operations at PFRR and employee traffic.

Although data are not readily available to characterize the naturally occurring sound levels within PFRR's downrange lands, the National Park Service **(NPS 2008)** conducted such a study during summer in nearby Denali National Park. Average sound levels ranged from approximately 23 decibels A-weighted (dBA) to 41 dBA, depending upon site. The highest sound levels were recorded at a location near flowing water and elevated levels of aircraft activity. It is acknowledged that the land areas may experience different seasonal use patterns; however, the information collected may serve as a reasonable proxy of conditions within the PFRR launch corridor.

4.5.2 No Action Alternative

As stated in Chapter 3, Section 3.5, sources of noise from daily activities at the PFRR launch site include ventilation systems, delivery vehicles, and employee vehicles. Continued launch and recovery of NASA sounding rockets would be consistent with existing sources of noises at PFRR and no additional impacts are anticipated under the No Action Alternative.

Launch Operations

Noise generated by the suborbital SRP flights can be grouped into three general categories: launch noise, flight noise, and landing noise. Launch noise is heard primarily in the immediate vicinity of the launch site. Flight noise and landing noise have not been investigated in this detail because they are at heights at which the noise cannot be heard or in areas where humans are not expected to be, such as near impact points for returning spent stages. Far-field sound levels of sounding rocket launches are presented in **Table 4–16**. The four most powerful rocket motors in the NASA SRP that have previously been used at PFRR are Talos (the first stage of the BB XII), Taurus (the second stage of the BB XII), Terrier, and Nike, listed beginning with the most powerful. These sound levels will persist for a fraction of a minute as the launch vehicle gains altitude. Increasing distance and atmospheric attenuation then sharply reduce the sound level at the ground.

Table 4–16. Far-Field Sound Levels Due to Sounding Rockets Program Rocket Launches

Launch Rocket	Overall Sound Power (kNm/s)	Maximum Sound Levels (dBA) at Distances (D) from Launch Pad		
		D = 1 km	D = 3 km	D = 11 km
Talos	2,700	110	97	75
Taurus	2,700	110	97	75
Terrier	1,700	110	96	74
Nike	990	107	91	71

Note: To convert kilometers to miles, multiply by 0.6214.
Key: D=distance; dBA=decibels A-weighted (referenced to 20 micro Pascals), km=kilometers; kNm/s=kilo Newton-meter per second.
Source: NASA 2000.

Sounding rockets reach supersonic speeds very quickly (*i.e.*, after several seconds); however, they generally would not generate a sonic boom noticeable on the ground due to their high angle of ascent **(Downing 2011)**. As long as a rocket's motors are burning, noise would be generated, especially at the lower altitudes when the air density is appreciable. Above a 10-kilometer (6-mile) altitude, where vacuum conditions are approached, no sound would be propagated. In the case of a typical T-IO launched from PFRR, the vehicle reaches this altitude at approximately 15 seconds into flight; a typical BB XII would be expected to reach the same height at just over 25 seconds of flight time.

When the rocket's motors are no longer burning, only aerodynamic noise would prevail. As the spent rocket stages reenter the Earth's atmosphere at supersonic speeds, sonic booms may be heard on the ground; however, they would be very small when compared to commonly encountered sources of sonic booms, including jet aircraft. The sonic boom analysis indicated that a typical reentering BB XII fourth stage would generate a sonic boom of approximately 0.2 pounds per square foot, equating to an instantaneous peak sound level directly under the boom footprint of approximately 114 dB **(Downing 2011)**. The duration of the low-frequency sound would be very brief, at approximately 30 milliseconds. In an unrelated study of sonic booms of similar magnitude, observers on the ground who were operating the sonic boom recording equipment within the predicted footprint of the sounding rocket boom "heard the boom but felt that they would not have noticed it had they been engaged in an unrelated activity" **(Plotkin *et al*. 2006)**. By comparison, sonic booms generated by supersonic aircraft typically have overpressures 5 to 10 times as large (5 to 10 kilograms per square meter [1 to 2 pounds per square foot]) and last for 100 to 500 milliseconds.

Descending sounding rockets would be expected to drop below the speed of sound at approximately 9,000 meters (30,000 feet) altitude. Spent stages or incoming payloads traveling at subsonic speeds would produce a characteristic whistling sound, followed by a momentary impact-type sound as they land on soil, ice, or a water surface. Acoustic waves would propagate below the surface of solid ground or ice pack. The sound produced and spreading of sound waves through the ground would depend on the nature of the ground material; the presence of snow and ice should help cushion the blow. The impact noise of a stage or payload hitting the ice pack over the Arctic Ocean and possibly penetrating the ice pack was estimated to result in a low-frequency impulse noise of less than 190 dB (referenced to 1 micro Pascal). Based on the transmission loss curves presented by **Buck (1966)** and **Roth (2008)**, the low-frequency noise could be attenuated by 80 to 90 dB in 100 kilometers (60 miles). Higher-frequency noise would be attenuated much more rapidly.

In summary, the noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

Search and Recovery

Estimates of noise levels on the ground under search and recovery aircraft typical of those that may be used in support of search and recovery operations at PFRR are presented in **Tables 4–17** and **4–18**. Permit conditions for flights over Arctic NWR and Yukon Flats NWR request a minimum flight altitude of 610 meters (2,000 feet) AGL, except for takeoff and landing

(USFWS 2011a, 2011b). At this altitude noise levels on the ground would be between 60 and 65 dBA from an overflight of a fixed-wing aircraft. Noise levels from a hovering helicopter would be 51 dBA for a Bell 206 and 60 dBA for a Bell 214. Noise generated during search and recovery aircraft operations is of medium duration. Although no recovery operations would expose persons to unsafe noise levels, there is the potential for temporary annoyance if related sounds were heard within the context of the natural quiet of a wilderness, wildlife refuge, or recreation area. The quiet of uninhabited areas may be temporarily interrupted by aircraft activity from search and recovery operations. However, aircraft activity would be very infrequent (less than several flights total per year) and sounds of overflights are familiar to residents of these areas, who rely on aircraft as a primary means of year-round transportation.

Table 4–17. Typical Noise Levels at Ground Level Under Fixed-Wing Aircraft Operations (decibels A-weighted)

Altitude (meters AGL)	Aviant Husky	Short Skyvan
91	82	86
150	76	81
305	68	73
460	65	69
610	60	65

Key: AGL=above ground level.

Note: Aviant Husky or comparable fixed-wing aircraft would be used for search operations and shorter-range recovery operations. The Short Skyvan or comparable aircraft would be used for longer-range recovery operations. To convert meters to feet, multiply by 3.281. Levels indicated are the maximum sound levels in decibels A-weighted (referenced to 20 micro Pascals).

Table 4–18. Typical Noise Levels at Ground Level Under Helicopter Operations (decibels A-weighted)

Altitude (meters AGL)	Bell 206 Jet Ranger		Bell 214 Huey II	
	Constant Speed Departure	Hovering	Constant Speed Departure	Hovering
8	N/A	98	N/A	110
15	N/A	91	N/A	102
91	82	71	88	82
150	77	66	83	76
305	70	59	76	68
460	67	55	72	64
610	63	51	68	60

Note: The Bell 206 Jet Ranger or a comparable helicopter is typically used for search and recovery operations when the payload or spent stage is within the lift capability of this lighter helicopter. The Bell 214 Huey II or comparable helicopter is typically used for recovery operations when the spent stage is heavier than the lift capability of the Bell 206 Jet Ranger. To convert meters to feet, multiply by 3.281. Levels indicated are the maximum sound levels in decibels A-weighted (referenced to 20 micro Pascals).

Key: AGL=above ground level; N/A=not applicable.

In summary, the adverse noise impact from search and recovery operations would be regional in scope, medium-term, and minor.

4.5.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.5.3.1 *Launch Operations*

Under Alternative 1, noise impacts from routine operations and launch activities would be similar to those under the No Action Alternative. The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional in scope, adverse, short-term in duration, and minor in intensity.

4.5.3.2 *Search and Recovery*

Estimates of noise levels on the ground under search and recovery aircraft would be similar to those under the No Action Alternative, but the number of search and recovery operations would be greater. Accordingly, the noise impact from search and recovery operations would be greater than the No Action Alternative.

A key difference between Alternative 1 and the No Action Alternative is the level of recovery of spent rocket stages. Under the No Action Alternative, the payloads that would be recovered would most likely return to land via parachute, requiring relatively little on-the-ground manipulation that could generate elevated sound levels. In the case of removing spent stages, some of which would land and embed nose-down, it is likely that power tools could be needed to cut the motor into manageable sized pieces or to cut off the stage to below ground level in a case where full removal would cause more damage than partial removal. The most likely power tool employed would be a gasoline-powered “cut-off saw,” which has been found to generate sound levels of approximately 95 dBA at 1.5 meters (5 feet) distance (estimated at 108 dBA at the source) when cutting steel rebar **(Eaton 2000)**.

The rate at which the sound from these activities would attenuate would be highly dependent upon where the work is taking place and the weather conditions. For example, conducting a recovery and disassembly operation on a day with little wind within an open, rocky area with little buffer between the activity and a receiver could result in sound levels in excess of 40 dBA at 1.1 kilometers (0.7 miles). However, performing the same work within an area of dense conifers could result in additional attenuation on the order of 5 dB for every 30 meters (100 feet) of distance (per the curves presented in **Aylor [1971]**), resulting in 40 dBA at an approximate distance of 120 meters (400 feet).

The presence of deep powder, which would occur on downrange lands during recovery of an off-nominal flight in winter, can also provide substantial attenuation (and was not considered in either case presented above), further reducing the intensity of the sound. A study conducted for the National Park Service by the U.S. Department of Transportation found deep snow to provide an additional attenuation of nearly 5 dB per doubling of distance from the source **(USDOT 2008)**.

In summary, sound levels generated from disassembly of rocket motors would likely be above background levels within the downrange lands; however, in either scenario, the sound generated would be short-term (*i.e.,* generally less than an hour per motor), infrequent, and depending on specific conditions, would be confined to a limited distance from the source.

Overall, noise generated by Alternative 1 search and recovery would be considered regional in scope, adverse, medium-term in duration, and moderate in intensity.

4.5.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.5.4.1 *Launch Operations*

Under Alternative 2, noise impacts from routine operations and launch activities would be similar to those under the No Action Alternative and Alternative 1. The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent-stage reentry and impact would be regional in scope, adverse, short-term in duration, and minor in intensity.

4.5.4.2 *Search and Recovery*

Estimates of noise levels on the ground under search and recovery aircraft would be similar to those under the No Action Alternative and Alternative 1, but the number of search and recovery operations would be greater. Accordingly, the noise impact from search and recovery operations would be the greatest of the alternatives and considered regional in scope, adverse, medium-term in duration, and moderate in intensity.

4.5.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Noise impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.5.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas.

4.5.5.1 *Launch Operations*

The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

4.5.5.2 *Search and Recovery*

Since the Wild and Scenic River segments or Wilderness Areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential noise impacts on visitors.

The noise impact from search and recovery operations would be regional, adverse, medium-term, and moderate in intensity.

4.5.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Noise impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.5, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas.

4.5.6.1 *Launch Operations*

The noise impact from routine PFRR activities, employee vehicles, and delivery vehicles would be regional, adverse, long-term, and minor. The noise impact from rocket launches and spent stage reentry and impact would be regional, adverse, short-term, and minor in intensity.

4.5.6.2 *Search and Recovery*

Since Wild and Scenic River segments or Wilderness Areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential noise impacts on visitors.

The noise impact from search and recovery operations would be regional, adverse, medium-term, and moderate in intensity.

4.5.7 Summer Launches

The noise generated from rocket launches and spent stage reentry and impact would continue to be regional, adverse, short-term, and moderate. The noise generated from search and recovery operations would not likely change and would continue to be regional, adverse, medium-term, and moderate.

4.6 VISUAL RESOURCES

4.6.1 Methodology

Visual resource assessments in this section are based on a description of the viewshed and the U.S. Bureau of Land Management's (BLM's) visual resource management (VRM) classification **(USDOI 1986a)**. A qualitative visual resource analysis was conducted to determine whether disturbances associated with the launch and recovery of NASA sounding rockets launched from PFRR would alter the visual environment of the PFRR launch site or launch corridor. Both the degree of contrast between the alternatives and the existing visual landscape and the visual impact of a person discovering a payload or spent stage are presented. The ROI for visual resources includes areas within the PFRR launch site and the PFRR launch corridor. The BLM VRM classification is further described in Chapter 3, Section 3.6, of this EIS.

An impact to visual resources would be considered major if a component of an alternative were to change the overall appearance of the ROI and would result in a change in the BLM VRM classification. A moderate impact would result in a change in the visual appearance of an area within the ROI and result in a change in the BLM VRM classification; however, the change would be limited to a 2-kilometer (1-mile) radius surrounding the payload or spent stage. A minor to negligible impact would result when there would be little or no change to the visual appearance of the ROI, there would be no change to the BLM VRM classification, and the visual impact would be limited to the immediate area surrounding the payload or spent stage. Regarding duration, a visual impact would be considered long-term if the effect lasted longer than 5 years, as could be the case if a payload or spent stage were left in an area with high visibility for more than 5 years; medium-term if the payload or spent stage were left unrecovered in an area with high visibility for 1–5 years; and short-term if the payload or spent stage were recovered within 1 year of being launched or located in an area with high visibility.

4.6.2 No Action Alternative

4.6.2.1 *Launch Operations*

Launch Site

The PFRR launch site consists of a developed area with offices, rocket launch facilities, a blockhouse, pad support, and a rocket storage building. Under the No Action Alternative, no measurable changes would be made to the appearance of the PFRR launch site.

Rocket Flight

During the launch of a sounding rocket, the vehicle propels a scientific payload to the upper atmosphere, after which the payload and spent rocket stages fall back to Earth along a parabolic trajectory. Most launches would occur at night. When launched, the sounding rocket can be seen for approximately 20 seconds from the PFRR launch site before disappearing. **Figure 4–6** shows a NASA sounding rocket launch from PFRR in April 2011.

Figure 4–6. Sounding Rocket Launch at Poker Flat Research Range

The impact on visual resources from the launching of sounding rockets would be minor and short-term. No change in BLM VRM classification **(USDOI 1986a)** would be anticipated for the areas within the PFRR launch corridor.

Flight Hardware

When the payloads and spent stages return to the Earth, they land within the PFRR launch corridor. **Figures 4–7** through **4–9** show sounding rocket stages that have landed within the PFRR launch corridor. Payloads and spent stages that would occur under the No Action Alternative would have similar appearances, as presented in Figures 4–7 through 4–9.

Figure 4–7. Spent Stage Within Poker Flat Research Range Launch Corridor

Figure 4–8. Aerial View of a Payload Within Poker Flat Research Range Launch Corridor

Figure 4–9. Payload Within Poker Flat Research Range Launch Corridor

Discovery of spent stages or payloads within the PFRR launch corridor could negatively impact some visitors' experience. Others may find it a positive experience to discover a spent stage or payload. In 2010 and 2011, the University of Alaska Fairbanks (UAF) and NASA received feedback from users of the areas within the launch corridor who have located spent stages and payloads. The comments received expressed both positive and negative reactions of these visitors from locating the spent stages and payloads within the launch corridor. The visual impact would be on a person-by-person basis and would be influenced by the perception of the individual.

The intensity of the impact would be dependent upon where flight hardware is located and how often it is seen by users of the downrange lands. It is likely that given the remote and vast nature of the launch corridor, many stages and payloads would go unnoticed. In that case, there would be little or no impact. In contrast, although the physical extent of the impact site would be small and limited to the area immediately surrounding the payload or spent stage (thereby deemed minor in most circumstances), its long-term presence in a high-value environmental feature such as a Wild River or Wilderness Area would most likely be considered a moderate impact. The duration of impacts on visual resources would vary depending on how long the stages and payloads were left unrecovered. In general, few payloads (and even fewer stages) would be recovered. Accordingly, impacts would most likely be long-term.

4.6.2.2 *Search and Recovery*

Searches for the payloads and spent stages would be conducted by fixed-wing aircraft, as discussed in Appendix F. Due to the vastness of the PFRR launch corridor, payloads are often not visible and difficult to locate. Brightly colored parachutes are deployed with some payloads to assist in the recovery of these payloads. **Figure 4–10** shows an aerial view of a payload recovered from the PFRR launch corridor. **Figure 4–11** shows an aerial view of the same payload with the parachute deployed as presented in Figure 4–10, except from a higher altitude. An arrow is provided in the picture to help with locating the parachute in the figure.

Figure 4–10. Aerial View of a Payload with Parachute Deployed

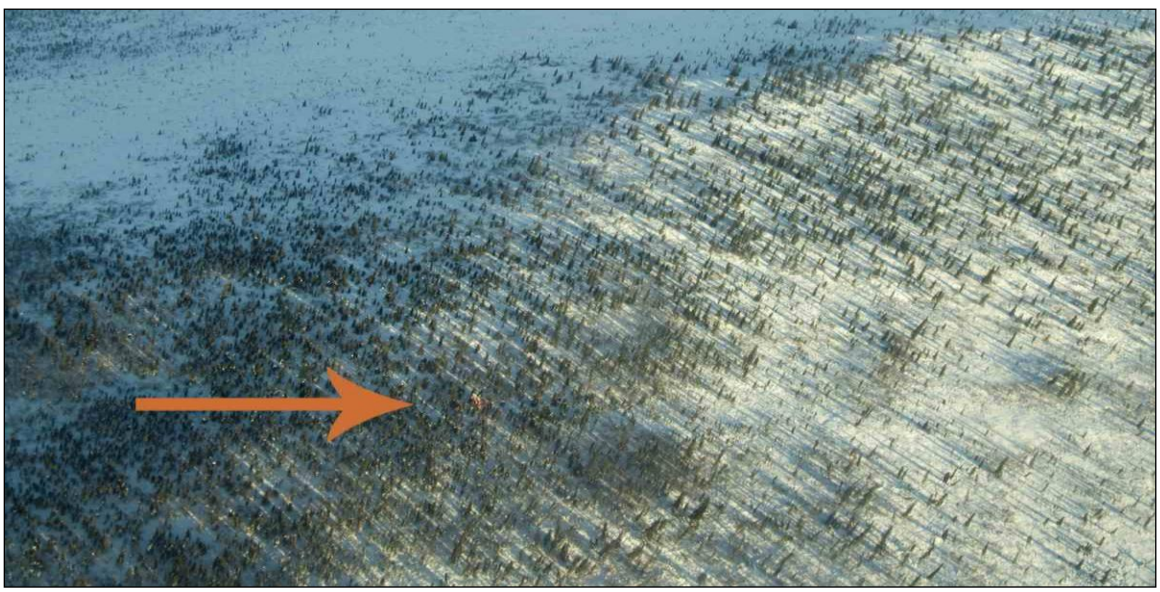


Figure 4–11. Higher Altitude of Aerial View of a Payload with a Parachute Deployed

Once located, the payloads and spent stages would be removed by helicopter, either by transporting to a nearby airstrip or to PFRR. Users of and visitors to subject lands would be able to see the aircraft performing search and recovery activities. Because of the long distances, remoteness, and climate, much of the state of Alaska is accessible only by general aviation aircraft. There are 18 rural airports and a number of unmarked airstrips in or near the PFRR launch corridor. As such, the additional presence of aircraft for search and recovery operations associated with the No Action Alternative would not have a measurable impact on the visual characteristics or BLM VRM Class of the PFRR launch corridor.

4.6.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.6.3.1 *Launch Operations*

Launch Site and Rocket Flight

Visual impacts from launch operations under Alternative 1 would be consistent with the impacts associated with the No Action Alternative and would be short-term and minor.

Flight Hardware

As compared to the No Action Alternative, the same amount of hardware would land within downrange properties. As such, the type and intensity of the impact would be similar. However, recovery of additional payloads and spent stages would reduce the probability of a visitor or user of the lands encountering such materials, thereby reducing the long-term visual impact.

4.6.3.2 *Search and Recovery*

The type of visual impacts from search and recovery activities under Alternative 1 would be consistent with the impacts associated with the No Action Alternative. However, attempted recovery of additional payload and spent stages would require additional aircraft to be flown over the PFRR launch corridor. Accordingly, the potential for a visual resource impact would be greater. However, when considered within the context of the existing aircraft traffic within the PFRR launch corridor, the large areas covered, and the infrequency of these operations, visual impacts from the additional air traffic are anticipated to be negligible. No change in the BLM VRM classification would be expected due to search and recovery activities under Alternative 1.

4.6.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.6.4.1 *Launch Operations*

Launch Site and Rocket Flight

Visual impacts from launch operations under Alternative 2 would be consistent with the impacts of the No Action Alternative and Alternative 1.

Flight Hardware

As compared to the No Action Alternative and Alternative 1, the same amount of hardware would land within downrange properties. As such, the type and intensity of the impact would be similar. However, as this alternative would entail the greatest efforts for recovery of payloads and spent stages, it would likely present the least probability of a visitor or user of the lands encountering such materials, thereby reducing the long-term visual impact.

4.6.4.2 *Search and Recovery*

The type of visual impacts from search and recovery activities under Alternative 2 would be consistent with the impacts associated with the No Action Alternative and Alternative 1. However, attempted recovery of additional payload and spent stages would require the most aircraft to be flown over the PFRR launch corridor. Accordingly, the potential for a visual resource impact would be greater. However, when considered within the context of the existing aircraft traffic within the PFRR launch corridor, the large areas covered, and the infrequency of these operations, visual impacts from the additional air traffic are anticipated to be negligible.

No change in the BLM VRM classification would be expected due to search and recovery activities under Alternative 2.

4.6.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Visual impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.6.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas. Since these areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential visual impacts on visitors.

4.6.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Visual impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.6.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could result in lower probabilities that future rocket launches from PFRR would impact in these areas. Since these areas may attract a greater number of visitors due to their designations, avoidance of these areas would result in fewer search and recovery actions within the area and less potential visual impacts on visual resources.

4.6.7 Summer Launches

As more activities would occur within the PFRR launch corridor during non-winter months, the potential for someone to observe a rocket overflight would be greater. However, the visual impact from such activities would continue to be short-term and minor. Regarding flight hardware, the type, magnitude, and duration of impacts would remain generally the same. However, in the absence of frozen ground and ice during the summer in areas of lower elevation, there is the potential that spent stages (particularly those that are fin-stabilized) would bury themselves in shallow bogs and sloughs (particularly in the wetland areas of the Yukon Flats), thereby negating the likelihood of a lands user encountering such materials.

Additionally, there is the potential that a lands user would observe a post-launch fixed-wing search operation within the PFRR launch corridor; however, the impacts would be short-term and negligible when considered within the context of the infrequency of a non-winter launch and the number of aircraft that are typically within the area supporting existing recreational and commercial activities.

4.7 ECOLOGICAL RESOURCES

This section describes potential impacts of each alternative on ecological resources in and around PFRR and the launch corridor. The categories of ecological resources will be analyzed in the same sequence as presented in Chapter 3, Section 3.7.

4.7.1 Methodology

The analysis encompasses direct and indirect effects on biological resources, including threatened and endangered species, associated with the following aspects of the NASA SRP at PFRR:

1. NASA SRP launches from PFRR,
2. descending spent stages and payloads,
3. search and recovery of spent stages and payloads, and
4. unrecovered spent stages and payloads.

Effects on ecological resources would mainly occur as a result of localized land disturbance, in which a spent stage or payload comes to Earth, and as a result of potential disturbances to wildlife caused by low-altitude overflight of aircraft associated with search and recovery operations. An area of 6–15 square meters (65–160 square feet) was used to evaluate the lethal area of impact for both vegetation and wildlife. It was assumed that the potential for disturbance would decrease rapidly as distance from the actual impact point increased. Historical data were used as a guide for analyzing past, as well as future, impacts.

Since launches would take place in the winter months (October through April), it was assumed that snow and ice cover would minimize effects on vegetation and subterranean or underwater wildlife. In addition, seasonal variation was taken into consideration when evaluating impacts on migratory or otherwise highly mobile species. The potential for effects on threatened, endangered, proposed, and candidate species and their habitats was evaluated in greater detail in recognition of their status.

Vegetation

Vegetation impacts evaluated in this section are addressed by ecoregion. The intensity of impact is categorized as negligible, minor, moderate, or major according to the definitions in Table 4–1. Direct impacts on vegetation and habitat are considered short-term if a functional vegetative cover is expected to reestablish within 1–2 years or less; moderate-term, within 3–5 years or less; and long-term, 5 years or longer. Reestablishment of functional vegetation cover is considered to be development of cover of herbaceous or woody plants capable of holding the soil.

Continued successional processes such as establishment of longer-lived plant species or growth of trees would be expected after reestablishment of functional vegetative cover.

Wildlife

To determine potential impacts on wildlife, this section relies heavily on available published literature evaluating the response of wildlife to noise associated with sounding rocket launch; overflight; descent, including sonic booms and impact on the surface; as well as the response to overflight by fixed-wing aircraft and helicopters used in search and recovery activities.

Potential noise levels generated by the alternatives were derived using industry-accepted noise modeling to define noise levels from rocket launch and descent and from aircraft and helicopters engaged in search and recovery activities (see Section 4.5).

Special-Status Species

For endangered and threatened species, additional considerations specific to the Endangered Species Act (ESA) are applied. A major impact would reach the scale at which multiple "takes" of more than one listed species would occur, or if the expected impact on a single species was such that a consulted expert agency (*i.e.,* U.S. Fish and Wildlife Service [USFWS] or National Oceanic and Atmospheric Administration [NOAA] Fisheries Service) would conclude that the species' recovery or continued existence might be in jeopardy. As defined under the ESA, "take" includes death, harm, or harassment of an individual. An impact would be considered moderate if an alternative had the likelihood of "taking" a single individual from more than one listed species or multiple individuals from a single species, but would not result in jeopardy as outlined above. A minor impact would occur if a single take were anticipated for a single species. An impact would be considered negligible if the likelihood of "take" were to be "insignificant and discountable" as defined by the ESA. Per the ESA, an "insignificant and discountable" impact is generally defined as one that would be very small in size and highly unlikely to occur. For species having designated critical habitat, a determination is made as to whether there would be adverse modification of critical habitat.

To best predict the likelihood of potential impact on listed species, calculations were performed to predict the likelihood of a descending payload or spent stage directly impacting or landing within their expected range. The methodology employed is very similar to that relied upon by NASA when assessing flight safety risk for a sounding rocket mission. Best available data on population densities were used.

4.7.2 Applicable Permit Conditions

The following is a summary of the stipulations from the most recent USFWS and BLM permits that are most applicable to the ecological resources analysis (see Appendix C for full permits). Under all permits, PFRR is required to contact the respective landowner prior to attempting a recovery action.

Stipulations of the 2011 Yukon Flats NWR permit include the following restrictions on launch operations and aircraft use:

Seasonal Restrictions on Launch Operations

- Rocket or debris impacts within Yukon Flats NWR are prohibited from May 1 through September 30 to avoid periods of high public use. A provision is made enabling exceptions to the seasonal restriction to be provided for specific time periods and areas, given appropriate justification.

Restrictions on Aircraft Use

- Aircraft are recommended to maintain a minimum of 610 meters (2,000 feet) AGL over refuge lands, except during takeoff, landing, and when safety considerations require a lower altitude.[4]

- The operation of aircraft at altitudes and in flight paths resulting in the herding, harassment, hazing, or driving of wildlife is prohibited.

- Landing of helicopters is authorized only in direct support of the recovery activities or in emergencies.

- Clearing of vegetation for landing/takeoff is prohibited, as well as low-level slinging of gear from site to site.

- Helicopter activity is prohibited within 0.8 kilometers (0.5 miles) of active raptor nest sites on cliffs or bluff faces during the period from May 1 through August 15.

The Special Use Permit for Arctic NWR also includes restrictions associated with the wilderness and wildlife use areas:

Restrictions on Mollie Beattie Wilderness Area

- Conducting launches with a planned impact site within the Mollie Beattie Wilderness Area is prohibited.

- Recovery of rockets or debris that enters the wilderness area inadvertently may be authorized on a case-by-case basis by the Arctic NWR manager in consideration of the appropriate action under the Wilderness Act of 1964.

Restrictions on Wildlife Use Areas

- Activities may not occur in some special use areas and/or during some time periods (*e.g.,* caribou calving, snow goose staging, Sadlerochit Springs). Special area boundaries or the effective dates may be modified by the Arctic NWR manager as needed.

[4] This permit condition was recently discussed with USFWS as the recommended altitude would be too high thereby precluding effective search operations. It was agreed upon that the recommended altitude would be maintained when transiting from the airfield to anticipated rocket hardware location, and that lower altitudes (*e.g.,* approximately several hundred feet AGL) would be necessary (and permissible) when searching.

- Specific authorization to use localities within special areas may sometimes be obtained on a case-by-case basis, depending on the location of animal concentrations, access route, proposed activity, etc.

- Unless specifically exempted, all activities, including helicopter flights, are prohibited within one-half mile of occupied raptor nest sites at the locations and during the time periods that follow: (1) north of the continental divide, March 15–August 15; and (2) south of the continental divide, April 15–August 15.

Stipulations of the BLM-issued permit include:

- All operations are to be conducted in such a manner as not to cause damage or disturbance to any fish or wildlife and subsistence resources.

- Excavation or disturbance during the recovery needs to be filled to avoid water ponding, soil erosion or thermokarsting (localized soil subsidence caused by melting of permafrost).

- Minor clearing of brush (less than 6 meters by 6 meters [20 feet by 20 feet] total area) for extracting rocket parts is allowed, although extensive clearing of trees or brush for helipads is prohibited.

- Appropriate action is required to clean equipment used to recover flight hardware to prevent propagating invasive and noxious weeds and plant species at recovery sites.

- Aircraft are required to fly at a minimum of 457 meters (1,500 feet) AGL within a half-mile radius of priority raptor species' nest sites from April 15 through August 15 (except March 15 through July 20 for gyrfalcons).

4.7.3 Vegetation

4.7.3.1 *No Action Alternative*

Launch Operations

There would be no impacts on vegetation at the launch site because the surrounding area is cleared and maintained free of vegetation. Upon landing of flight hardware, impacts on vegetation would be restricted to the area immediately surrounding the item(s) and would diminish rapidly as distance from the impact point increases. Impacts would generally not be observable more than about 5 meters (approximately 16 feet) from the impact point. Since the majority of launches would be conducted during the winter months (October to April), when substantial snow cover is present, minimal impacts on vegetation are anticipated. Given the small and localized area of disturbance and the small number of launches annually, potential adverse impacts on vegetation and habitat would be negligible.

Due to the large area under the PFRR launch corridor and the dispersion characteristics inherent in sounding rocket flights, it is not possible to provide estimates for each plant species or habitat type that could potentially be disturbed. However, the number of spent stage and payload impacts within each ecoregion has been calculated for the last 15 years of launches from PFRR and is presented in **Table 4–19**. If future impacts follow a similar pattern, the data could be used to estimate the number of impacts affecting each ecoregion.

Table 4–19. Percentage and Number of Spent Stages and Payloads that Have Landed in Each Ecoregion, 1997–2011

Ecoregion (Ecoregion number)	Percent (Number) of Impact Points (n=112)	Total Area Impacted[a] (square meters)	Percent of Ecoregion Impacted by Combined Stages and Payloads
Brooks Range (103)	19 (21)	1,680	4.0×10^{-6}
Interior Highlands (105)	63 (71)	5,680	2.5×10^{-5}
Interior Forested Lowland (104)	5 (6)	480	3.3×10^{-6}
Yukon Flats (107)	4 (4)	320	1.3×10^{-6}
Arctic Coastal Plain (101)	0 (0)	0	0
Arctic Foothills (102)	0 (0)	0	0
Beaufort Sea	9 (10)	800	2.4×10^{-5}

a. An 80-square-meter disturbance area was used to estimate disturbance based on a circular area with a radius of 5 meters; generally, ground disturbance would be confined to a much smaller area.

Note: To convert square meters to square feet, multiply by 10.7639.

Source: NASA 2011a.

The data show the small and insignificant cumulative area of disturbance by ecoregion resulting from the past 15 years of launches from PFRR.

Search and Recovery

Recovery operations with the potential to impact vegetation are limited to the "on-the-ground" activities associated with helicopter landing and rigging the payload to the helicopter. It is anticipated that during this time period, vegetation could be crushed, uprooted, or otherwise disturbed in a localized area. Such disturbances are expected to be very small in area, temporary, and would be naturally mitigated through succession and natural regrowth. Landing by fixed-wing reconnaissance aircraft would have minimal impacts because landings would be limited to existing airstrips or areas lacking obstacles and with naturally occurring low vegetation such as gravel beds. Because of the small and isolated area of vegetation affected by a single payload recovery, and natural vegetative regeneration, adverse impacts on vegetation would be negligible under the No Action Alternative.

In the unusual event of a wintertime (October to April) recovery, adverse impacts on vegetation would occur to an even lesser degree due to the presence of frozen ground and snow cover.

4.7.3.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

Ground-disturbing activities associated with launch operations at PFRR under this alternative would be similar to those associated with the No Action Alternative and Alternative 1 since the same number of launches per year is anticipated.

Search and Recovery

Under Alternative 1, search and recovery of newly spent stages and payloads would be made to the extent practical and done in an environmentally responsible manner. Although the same types of impacts on vegetation would occur as under the No Action Alternative (localized crushing, uprooting), the number of stages and payloads recovered is anticipated to increase. Thus, the areal extent of the impacts would also increase. Because of the low number of recovery efforts annually, the small and isolated area of vegetation affected by recovery of a spent stage or payload, and the natural regeneration of vegetation after disturbance, adverse impacts on vegetation would be negligible under Alternative 1.

4.7.3.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

Ground-disturbing activities associated with launch operations at the PFRR launch site under Alternative 2 would be similar to those associated with the No Action Alternative and Alternative 1 since the same number of launches per year is anticipated.

Search and Recovery

Impacts on vegetation as a result of recovery efforts under Alternative 2 would be similar to those under Alternative 1, except increased efforts would be made to recover existing payloads, as well as new and existing stages. The additional recovery efforts under Alternative 2 would add to the areal extent of disturbance to vegetation, although the types of disturbance would be the same as those described under the No Action Alternative. Because of the low number of recovery efforts annually, the small and isolated area of vegetation affected by recovery of a spent stage or payload, and the natural regeneration of vegetation after disturbance, adverse impacts on vegetation would be negligible under Alternative 2.

4.7.3.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Impacts on vegetation under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.7.4.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on vegetation within PFRR and any adverse impacts of launch and recovery activities on vegetation would be negligible as described above.

4.7.3.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Impacts on vegetation under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.7.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential impacts on vegetation within PFRR and any adverse impacts of launch and recovery activities on vegetation would be negligible as described above.

4.7.4 Wildlife

This section describes potential impacts on wildlife occurring within the ROI as a result of the alternatives. For purposes of impact analysis, wildlife includes terrestrial mammals, marine mammals, birds, and fish. Species protected under Federal or state endangered species legislation is discussed separately in Section 4.7.7.

The composition of species within the ROI would change depending on season. For example, from October to April, species that overwinter within the PFRR launch corridor, such as the musk ox, would be present during winter launches, whereas migratory waterfowl and shorebirds would be absent during winter launches. Additionally, activities of species and their sensitivity to disturbance may vary with the season.

4.7.4.1 *No Action Alternative*

Launch Operations

Wildlife in the immediate vicinity of the PFRR launch site would be exposed briefly to the sound and light from each launch, which is moderate in intensity (up to 110 dBA at 1 kilometer [0.6 mile]; see Section 4.5). After ignition, the sound builds to its maximum volume in seconds as the rocket lifts off and then diminishes rapidly as it climbs. Winter launches would occur during darkness, when migratory species would be absent and most resident species would be inactive. Due to the infrequency of launches and the brief duration of associated noise, species present near the launch site are expected to have negligible to minor short-term behavioral responses, if any, to the sound and sight of a launch and are not expected to experience harm as a result.

The sounding rocket climbs to approximately 805 kilometers (500 miles) above the Earth's surface before beginning its descent. Descending spent stages and payloads would drop below the speed of sound about 9,000 meters (30,000 feet) AGL. A low-intensity sonic boom would be generated above 9,000 meters (30,000 feet). Although hearing response varies from species to species, it is unlikely that momentary (less than 1 half-second) exposure to a very low-intensity sonic boom would cause an adverse response in any wildlife species.

The subsonic sound associated with the incoming spent stage or payload was not commented upon by **Plotkin *et al*. (2006)**, but exposure to the subsonic sound would be brief in duration and would end as the payload or spent stage hits the surface. The sound of the payload hitting the surface would be related to its mass and velocity and to properties of the surface such as snow cover, vegetation, or rock (see Section 4.5). Disturbance of wildlife due to the sound and impact of a descending stage or payload would be infrequent because of the small number of annual launches and minimal due to the localized affected area. Effects would most likely be limited to a momentary interruption of routine behaviors, such as foraging, but could extend to individuals temporarily leaving the area immediately surrounding the point of impact. For example, an incoming item hitting the Earth within or very near a herd of caribou (a very unlikely event) could cause the animals to temporarily take flight in a response similar to one elicited by a potential predator. Adverse impacts would be short term and range from negligible to minor. Due to the low number of descending stages and payloads and their wide spatial dispersion, it is unlikely that any individual animal would be in proximity to more than one descending item during its lifetime.

The likelihood of a direct impact on an animal is extremely low due to the extent of the area under the PFRR launch corridor (113,000 square kilometers [43,600 square miles]), the small area of lethal impact (generally ranging from 6–15 square meters [65–160 square feet], depending on the rocket type and stage number), and the small number of estimated annual launches (an average of 4). The potential for injury or disturbance would decrease rapidly with distance from the impact point. The chances of a direct impact due to a payload or spent stage striking an individual animal are therefore negligible.

In summary, adverse impacts on wildlife from launch, flight, and landing of spent stages or payloads would be short-term and could range in magnitude from negligible to minor.

Search and Recovery

Whenever feasible, a search plane would attempt to find spent stages and payloads after launch and document their locations for later recovery. Recovery activities would typically be conducted during summer months, when weather conditions and day length are more favorable for search and recovery activities.

The literature contains a variety of reports of wildlife exhibiting potentially adverse responses to aircraft overflight (*e.g.,* **NPS 1994**); however, conducting well-controlled studies on unconfined wildlife is difficult and relatively few are available.

Terrestrial Mammals

Ungulates (hooved mammals) occupying landscapes with little cover, such as caribou, have been the subject of focused studies because of a concern that a response such as running in response to an aircraft overflight might be of high energetic cost. An additional, perhaps greater concern, is that disturbance during calving season (generally May through June) could lead to a cow (female) abandoning her young.

The PFRR launch corridor overlaps the range of two important caribou herds, the Central Arctic Herd and the Porcupine Caribou Herd. In addition, range of the relatively smaller White Mountains herd is located north of the launch site within the White Mountains NRA. Accordingly, most of this section will focus on potential effects on these animals. Areas of concentrated calving for the Central Arctic and Porcupine herds occur along the northern coast of Alaska, an area that has very low probability for sounding rocket hardware landings due to protection of nearby towns (*e.g.,* Kaktovik) and infrastructure (offshore oil and gas platforms). Performing a recovery operation in this area, although possible, would be highly unlikely. The most likely areas that caribou would be encountered during recovery would be migratory routes and summer and wintering grounds, particularly in the Brooks Range vicinity. Although there is limited information regarding the distribution of the White Mountains herd, available data suggest that calving occurs mostly east of Beaver Creek. In the event that a recovery operation is planned to occur in an area where the White Mountains herd could potentially exist, coordination with BLM would occur in an effort to minimize impacts on the herd. Specifically, recovery operations would be timed to avoid sensitive periods of the caribou life cycle, including the calving and migration seasons **(Durtsche and Hobgood 1990)**.

A study conducted by **Calef *et al.* (1976)** concluded that barren-ground caribou reacted to small fixed-wing (*e.g.,* Cessna 185) and helicopter (*i.e.,* Bell 206) overflights most strongly during calving (late May to early June), post-calving (early June to late June) and winter. During the calving period and in early winter, and often during the rut, a substantial percentage of strong escape responses occurred when the aircraft were flying at 90–150 meters (300–500 feet) AGL. The authors suggest that if aircraft operate in level flight at heights above 150 meters (500 feet) during the spring or fall migration, most potentially injurious reactions by caribou would be avoided. To avoid the possibility of even mild escape responses, the authors recommended flying at a 305 meters (1,000 feet) altitude. These recommendations correspond well with the findings of two other caribou-focused studies **(Gunn and Miller 1978; McCourt *et al*. 1974)**, which document minimal reactions to aircraft at altitudes of approximately 300–400 meters (1,000–1,300 feet) AGL during both times of calving and post-calving. The study by **McCourt *et al.* (1974)** also evaluated disturbances to both moose and grizzly bear from fixed-wing overflight and found that altitudes over 183 meters (600 feet) AGL had negligible effects on moose, whereas grizzlies were more sensitive. For appropriate consideration of all species, the authors recommended a buffer of at least 305 meters (1,000 feet) AGL.

Gunn *et al.* (1985) documented the effects of helicopter (*i.e.,* Bell 206) overflight and landing on post-calving barren-ground caribou in the Northwest Territory, Canada. The authors observed that a helicopter overpass at 305 meters (1,000 feet) AGL, followed by a landing within 300–2,000 meters (100–6,600 feet) of aggregations of cow-calf pairs caused disruption of ongoing activities and elicited behavioral responses that led to displacements of at least 1–3 kilometers (0.6–1.8 miles).

Regarding difference in reaction between fixed-wing and rotary-wing (helicopter) aircraft, **McCourt *et al.* (1974)** noted that caribou were more responsive to helicopter than to small fixed-wing overflights only at low altitudes (below 100 meters [300 feet] AGL), whereas **Calef *et al.* (1976)** documented stronger responses to fixed-wing aircraft at altitudes below 150 meters (500 feet) AGL.

Lawler *et al*. (2004) reported on a study of the effects of military jet overflights on Dall sheep east of Fairbanks, Alaska. Like caribou, Dall sheep occupy terrain having little cover. The study could find no difference in population trends, productivity, survival rates, behavior, or habitat use between areas mitigated and not mitigated for low-level military aircraft. In a mitigated area, flights are restricted to above 1,500 meters (5,000 feet) AGL during the lambing season, whereas there were no such restrictions in the unmitigated areas.

In the rare case of a failed flight, snow machines could be used to effect an immediate response to the expected point of impact. Such responses would be expected to be limited to the areas adjacent to the launch site and would not span further north than the White Mountains. However, some disturbance to resident wildlife (*e.g.,* moose) could occur. A study conducted by **Colescott and Gillingham (1998)** found that moose within a 300-meter (1,000-foot) distance from snow machines may alter their behavior (*e.g.,* move to adjacent habitat); however, the measured effects were temporary and minor. When considered within the context of the infrequency of failed flights and the limited number of snow machine trips that would occur in such an event, potential effects of off-highway vehicle use on wildlife would be short-term and minor.

Birds

Large areas of the PFRR launch corridor are important breeding and staging areas for a variety of dabbling and diving ducks, geese, and swans. In particular, Yukon Flats NWR hosts some of the highest nesting densities of waterfowl in North America **(USFWS 1987)**. Most nesting occurs in May and June of each year, and therefore could be affected by search and recovery operations. The primary concern would be the potential to startle nesting females, potentially exposing eggs to thermal stress or an increased risk of predation. Studies of waterfowl, including ducks and geese, have shown (1) temporary behavioral responses to low-altitude overflight, ranging from assuming an alert posture to taking flight; (2) responses decreasing in magnitude as overflight elevation increases; and (3) rapid resumption of the behaviors exhibited prior to the overflight (*e.g.*, **Komenda-Zehnder *et al.* 2003**). The authors of the referenced study state that potential effects on waterbirds can be reduced substantially if aircraft maintain minimum altitudes of at least 450 meters (1,500 feet) for helicopters and 305 meters (1,000 feet) for fixed-wing aircraft. However, it is also noted that the birds within the study site were within an area of somewhat regular disturbance, which could have led to some habituation. Avifauna in more remote areas, such as the ROI, which may be less accustomed to such stimuli, could be more sensitive. Maintaining an altitude in excess of that recommended by the above study would be possible when transiting from the airfield to the expected search area and would ensure minimal effects. However, search operations would require a lower altitude, likely several hundred meters AGL, which would be expected to startle nearby waterfowl. When considered within the context of the No Action Alternative, it is reasonable to assume that the infrequency of such flights (approximately 1 per year), coupled with the already present air traffic in the area, would not lead to substantial effects.

Search and recovery activities within the PFRR launch corridor may be conducted during the nesting season of eagles and other raptors. Helicopters generally create a greater response at a given altitude or approach distance than do fixed-wing aircraft. Songbirds and raptors vary in their responses to overflight, but documented responses have been limited to short-term behavioral responses and no effects that would be measurable at a population level have been recorded. For example, **Windsor (1977)** conducted a study in which nine active peregrine nests were exposed to regular aircraft (fixed wing and helicopter) overflights ranging in altitude from 75 to 305 meters (250–1,000 feet). Of the nine nests, only one was abandoned. The other eight, however, showed no effect on hatch rate or fledging rate. Eagles and other raptors on nests or caring for young are less likely to respond to overflights or show response to overflights at greater distances than would non-nesting birds.

It is noteworthy that several studies have found that pedestrians tend to have the most extreme effects on breeding eagles when compared to boats, vehicles, short-duration noises, or aircraft **(Grubb and King 1991; Grubb *et al.* 1992)**. Although specific to bald eagles (which would not be expected to occur in sizeable numbers within the PFRR launch corridor), this information suggests that on-the-ground activities could be a greater disturbance to raptors than overflight. However, every recovery operation in the vicinity of an active nest would not necessarily elicit an adverse response. A clear line of sight is an important factor in a raptor’s response to a particular disturbance **(Suter and Joness 1981)**. In some instances, non-threatening activities in close proximity to nests may have minimal effects if the activity is visually or audibly buffered by vegetation or topography **(Knight and Temple 1995)**. Clearly, actual effects would vary and be highly situation-specific. In either case, potential adverse impacts would be minor as the land use permits summarized in Section 4.7.2 provide protection for raptors through stipulations of both minimum altitudes and lateral avoidance of active nests.

Marine Mammals

Search and recovery activities would not be conducted over marine mammal habitat on or adjacent to the Beaufort Sea, so marine mammal species would not be exposed to overflight associated with search and recovery activities.

Fish

Fish would not be affected at the sound levels associated with overflight at altitudes that would be utilized during search and recovery operations.

Summary

PFRR-sponsored single-engine search aircraft (*e.g.*, Aviat Husky) flying at altitudes greater than 150 meters (500 feet) AGL would generally be expected to cause minimal, if any, response from wildlife (based on data provided in reviews including **NPS 1994; Manci *et al*. 1988; Larkin 1994; Gladwin *et al*. 1987**). Similar aircraft are utilized by resource management agencies to survey waterfowl and game species at altitudes as low as 30.5 meters (100 feet) AGL **(USFWS 2011c)**. Lower-level flight, especially combined with maneuvering such as circling and landing at an identified hardware recovery site, may cause temporary and localized responses such as taking flight by waterfowl or running by ungulates (*e.g.*, caribou). Permit stipulations with USFWS recommend minimum altitudes of 610 meters (2,000 feet) AGL or higher for overflight over Yukon Flats NWR and Arctic NWR lands, which constitute the majority of the area within the PFRR launch corridor. Under these circumstances, no adverse impacts on wildlife from the overflight are expected.

Generally, helicopters approaching wildlife tend to evoke a behavioral response at a greater distance than do fixed-wing aircraft. However, the responses to helicopters range from negligible to minor at distances that would be involved in the search and recovery exercises, with the exception of landings and takeoffs, when, for example, nearby animals would move away from the site or take cover.

Overall, any adverse impacts on wildlife due to search and recovery operations would be localized to the vicinity of search and recovery activities, would be short-term in duration, and would range from negligible to minor.

In the event of an aircraft-based winter recovery, disturbances would be similar to those described under the “Launch Operations” section. Species with larger numbers and wider distributions under the PFRR launch corridor, such as musk ox and moose, would be more likely to be exposed to search and recovery activities than less common or more narrowly distributed species, but any adverse impacts would continue to be negligible due to their short duration and localized nature.

4.7.4.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

Since the same number of launches is anticipated to occur under Alternative 1 as under the No Action Alternative, any adverse impacts from launch operations on wildlife under this alternative would be similar to those described under the No Action Alternative and would be negligible.

Search and Recovery

The number of stages and payloads recovered under Alternative 1 is anticipated to increase compared to the No Action Alternative. Although the type of impacts on wildlife would be similar to those described under the No Action Alternative, the magnitude of any adverse impacts is anticipated to be higher based on the increased recovery effort. The areal extent of the impacts would also increase. However, any adverse impacts would be minor in intensity and short-term in duration due to the infrequent exposure to search and recovery aircraft over a very large search area and the short duration and localized nature of on-the-ground recovery activities.

4.7.4.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

Since the same number of launches is anticipated under Alternative 2 as under the No Action Alternative and Alternative 1, any adverse impacts from launch operations on wildlife under Alternative 2 would be similar to those described under the No Action Alternative and Alternative 1.

Search and Recovery

Under Alternative 2, the greatest efforts would be made to recover new and existing payloads and stages. Although the type of impacts on wildlife would be similar to those described under the No Action Alternative and Alternative 1, the magnitude of any adverse impacts is anticipated to be higher based on the increased recovery effort. However, any adverse impacts would remain minor in intensity and short-term in duration due to the infrequent exposure to search and recovery aircraft over a very large search area and the short duration and very localized nature of on-the-ground recovery activities.

4.7.4.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Impacts on wildlife under Alternative 3 would be nearly identical to those identified under Alternative 1 in Section 4.7.4.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. As such, these restricted trajectories could lessen the potential impacts on wildlife within these areas. However, any adverse impacts on wildlife are already considered to be negligible so any decrease in impacts is not expected to be substantial.

4.7.4.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Impacts on wildlife under Alternative 4 would be nearly identical to those identified under Alternative 2 in Section 4.7.4.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could lessen the potential impacts on wildlife within these areas. However, any adverse impacts on wildlife are already considered to be negligible so any decrease in impacts is not expected to be substantial.

4.7.5 Fisheries Management Plans, Essential Fish Habitat, and Subsistence Fisheries

Although there is a possibility for a payload or spent stage to descend into essential fish habitat (EFH), as designated under the 2009 Arctic Fisheries Management Plan, or the Salmon Management Plan, or into an area utilized as a subsistence fishery, for all alternatives, the probability of directly impacting a target species, such as the Arctic cod, or a subsistence species, such as pink salmon, would be so small as to be discountable. The salmon management plan EFH covers anadromous fish streams on the Alaska North Slope (north of the Brooks Range) that drain into the Beaufort Sea and are occupied by pink and chum salmon. The Arctic Management Plan EFH encompasses a 509,000-square-kilometer (approximately 200,000-square-mile) area of the Beaufort Sea out to 200 nautical miles that supports the Arctic cod.

Given the seasonal timing of launches, spent stages or payloads would land when the EFH is ice-covered and would enter the aquatic environment after penetrating the ice or during the seasonal breakup. Payloads and spent stages that enter the marine environment are expected to reach the ocean floor and lodge in oxygen-poor sediments or remain on the ocean floor and corrode or become encrusted by marine organisms **(USN 2011)**. Under normal conditions, spent stages are essentially inert aluminum or steel tubes after short periods of exposure to water (see Section 4.3). Unrecovered payloads contain battery constituents and other materials that would gradually leach into the water column, resulting in limited and localized contamination that would be rapidly dispersed by currents. Considering the limited number of launches per year (an average of four) and their likely geographic dispersion, ice coverage during the winter months when launches are proposed to occur, and the relatively small size of spent stages and payloads, negligible adverse impacts that would be localized and short-term in duration, both direct and indirect, are anticipated under all alternatives. Therefore, the project would not adversely affect EFH, target species, or subsistence species.

4.7.6 Endangered, Threatened, and Special Status Species

This section addresses potential impacts on listed, proposed, and candidate endangered or threatened species that USFWS and NOAA have identified as having the potential to occur within the ROI for all alternatives. There are no listed, proposed, or candidate species known to live in the vicinity of the PFRR launch site or under the launch corridor until it approaches the coast of the Beaufort Sea. Of the species shown in Chapter 3, Section 3.7.2.8, Table 3–13, the ringed seal (proposed threatened) and the polar bear (threatened) have the potential to occur year-round within the ROI and could be affected by descending payloads or spent stages. The bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate) are summer residents and would be absent during the winter season, when launches are proposed to occur and payloads and spent stages are expected to impact sea ice covering the Beaufort Sea (see Section 3.7.2.8, Table 3–13). Spectacled and Steller's eiders (threatened) are accidental in occurrence and uncommon within the ROI. They would also most likely be present during the summer months, if they were present at all.

No search or recovery activities would be conducted for payloads or spent stages that are predicted to land in the Beaufort Sea. In the unexpected event a spent stage or payload were discovered on the coastal plain and reported to UAF or NASA, recovery would be planned in consultation with cognizant resource agencies such that there would be no effect on listed species. No such recovery operations have been attempted to date and should not be considered a typical scenario.

As discussed in Chapter 3, Section 3.7.2.9, the BLM also keeps a list of sensitive species. National policy directs BLM state directors to designate BLM sensitive species in cooperation with the state fish and wildlife agency (BLM Manual 6840). The sensitive species designation is normally used for species that occur on BLM public lands and for which BLM has the capability to significantly affect the conservation status of the species through management **(USDOI 2012c)**. In addition to those species under the jurisdiction of USFWS and the Alaska Department of Fish and Game, a discussion of potential impacts to species listed as sensitive by the BLM is presented below. BLM-listed species with the potential to occur on or near BLM-owned land within the ROI include six bird species and one mammal; the American peregrine falcon, bald eagle, the trumpeter swan, the grey-cheeked thrush, the olive-sided flycatcher, the blackpoll warbler, and the Canada lynx.

Impacts to BLM-listed species are anticipated to be minimal and similar to those discussed in the above sections regarding disturbance to wildlife as a result of winter launch and recovery activities. The majority of the birds discussed in Chapter 3, Section 3.7.2.3, migrate south to warmer climates during the winter months; thus, no impacts to these species are anticipated from winter launch or recovery activities. The trumpeter swan, bald eagle, and lynx have the potential to occur within PFRR during winter launches and recoveries but due to the vast expanse of PFRR and relatively small-localized populations of these animals, no significant direct impact (such as mortality caused by contact with a descending spent stage) is anticipated. Minor indirect impacts could occur but would most likely be restricted to startling or otherwise scaring wildlife and potentially causing them to temporarily leave the affected habitat.

4.7.6.1 *Ringed Seal*

Launch Operations

Only the longest distance of sounding rockets, particularly the BBs X and XII, would have a likelihood of landing along the margin of the coastal plain, potentially affecting seals. Potential impacts on ringed seals from launch operations for all alternatives would be associated with reentering payloads and/or stages landing within seal habitat, and more specifically, seal concentration areas. During the months when the sea ice extends to the coast (October to June), ringed seals tend to concentrate on shorefast ice adjacent to the coastal areas of Alaska **(Marz 2004)**. From July to September, when the sea ice retreats northward and large stretches of open water appear along the coast, the seals tend to expand their range both northward and westward, diminishing their overall density in the project area.

Probability of Impact

To evaluate the probability of a direct impact adversely affecting a ringed seal, a typical 3-sigma impact ellipse was created for a spent stage or payload predicted to land in the Beaufort Sea (1,000 kilometers [620 miles] from PFRR). The large size of this ellipse (over 500,000 square kilometers [190,000 square miles]) is due to the various factors (such as winds) that affect the flight and descent of the unguided rocket. The impact point location is typical of launches from PFRR into the Beaufort Sea. Of the 24,000-square-kilometer (9,400-square-mile) winter habitat concentrated along the coast, only 45 square kilometers (17 square miles) were intersected by the ellipse (see Appendix G). This equates to a probability of approximately 2.0×10^{-5} (one chance in 50,000 per launch) that a spent stage or payload would land within the winter concentration area of the ringed seals (see Appendix G).

It is possible that ringed seals could exist throughout the Beaufort Sea on sea ice during the winter. Expected density values for ringed seal in areas of concentrated occurrence in the Beaufort Sea are 0.35 individuals per square kilometer (average density) and 1.42 individual per square kilometer (maximum density) for nearshore areas, where the seals are most concentrated, and 0.25 individuals per square kilometer (average density) and 1.00 individual per square kilometer (maximum density) for ice margins **(Ireland *et al.* 2009)**. Assuming a conservative density of 1 individual per square kilometer throughout the Beaufort Sea more sounding rockets could possibly impact and allowing for a 10-meter (33-foot) radius buffer zone around each seal, the per-launch chance of an impact near a ringed seal is very low, approximately 3.1×10^{-4}, or 1 chance in 3,200 (see Appendix G). .

Effects of Sound

As discussed in Section 4.5, the ballistic reentry of a representative stage or payload would generate a mild sonic boom at an altitude between 18,000 meters (60,000 feet) and 9,000 meters (30,000 feet) AGL. The peak instantaneous sound pressure received on the ice would be approximately 114 dB and would be of very low frequency (less than 100 hertz) **(Downing 2011)**.

In addition to the sonic boom, the stage or payload would eventually land on the presumably frozen surface of snow-covered ice, generating a momentary impulse sound conservatively estimated to be 130 dB in air and 192 dB in the water below the impact site.

Physiological Effects

A primary concern of sound exposure on pinnipeds is whether the source would result in either temporary or permanent hearing loss **Southall *et al*. (2007)** proposed exposure criteria for assessing the potential injury to pinnipeds in air exposed to a single sound pulse, such as a sonic boom. The authors recommended a 149 dB exposure criterion for injury from a single pulse in air. Likewise, a similar conservative criterion for injury (218 dB) was suggested for pinnipeds in water. Therefore, when considered within the context of these recommended criteria, the expected sonic boom and snow/ice impact of a reentering sounding rocket payload or stage would cause no temporary or permanent hearing damage to ringed seals.

Behavioral Effects

The same study **(Southall *et al.* 2007)** also proposed a 109 dB criterion for single pulse sound behavioral disturbance of pinnipeds in air. The criterion, noted by the authors as likely conservative, was mostly based upon observation of strong responses (*e.g.*, stampeding behavior) of some species, especially harbor seals, to sonic booms from aircraft and missile launches in certain conditions **(Berg *et al.* 2001, 2002; Holst *et al.* 2005a, 2005b)**. A 212 dB criterion for pinnipeds in water was proposed based upon the level at which some temporary hearing effects may be observed in some species.

The most notable sound-related behavioral response would be the potential for trampling and/or separation of young from females, especially following birth. PFRR launch operations could overlap the general birthing and suckling period (*i.e.*, mid-March to April). During much of this time, female seals and their young remain in snow dens, which have been found to be very effective in muffling sound **(Blix and Lentfer 1992)**. In the referenced article, the authors highlight one particular event during which a helicopter noise level of 115 dB was reduced to 77 dB in an artificial polar bear den covered by less than 1 meter (3 feet) of snow just 3 meters (10 feet) away. The snow dens were also found to be effective in absorbing vibration. Even with relatively modest attenuation, it may be concluded that in-den received sound levels from an incoming sounding rocket section would be below the criteria proposed by **Southall *et al.* (2007)** and would have negligible adverse effects. Furthermore, as nearly all of the sound energy of the sonic boom is below 75 hertz (the minimum estimated range of hearing as presented in **Southall *et al.* [2007]**), it is doubtful that boom-induced sounds received outside of dens would be detected by seals. Finally, the sound resulting from the impact on the snow and ice would not be expected to cause adverse effects on in-water individuals. Although this analysis cannot discount the possibility that ringed seals would hear (or have some reaction to) the sounds generated by stage and payload reentry, it is reasonable to conclude that such effects would be temporary and similar to other natural sounds in their marine environment, such as the sounds of ice cracking, popping, and colliding **(Greening and Zakarauskas 1994; Milne 1972; Milne and Ganton 1964; Xie and Farmer 1991)**.

Effects of Remaining Flight Hardware

Given the buildup of heat generated by friction with the atmosphere the reentering payload is expected to break apart and the pieces to sink into the ice to some degree where they would be frozen over and covered by drifting or blown snow. This is the same expected fate of a spent rocket stage, with the exception that it would be less susceptible to breakup. Based on the melting patterns of sea ice in the Beaufort Sea over the last few years **(NSIDC 2011)**, over 80 percent of the payloads and spent fourth stages are expected to land on sea ice that melts annually, at which time they would sink to the bottom of the ocean. Based on the same analysis, less than 20 percent of the payloads and spent fourth stages are expected to land on “permanent” ice (see Appendix G). Assuming an average of four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage). Considering the limited number of launches per year (an average of four), the relatively small size of spent stages and payloads, and the largely inert or non-reactive nature of the items, no adverse impacts on ringed seals and negligible adverse impacts on their habitat are anticipated.

Search and Recovery

Search and recovery operations for spent stages or payloads that land in the Beaufort Sea or on sea ice would not occur and would therefore have no effect on ringed seals or their habitat.

4.7.6.2 *Polar Bear*

Potential impacts on polar bears would be similar to those discussed above for the ringed seal.

Launch Operations

Probability of Impact

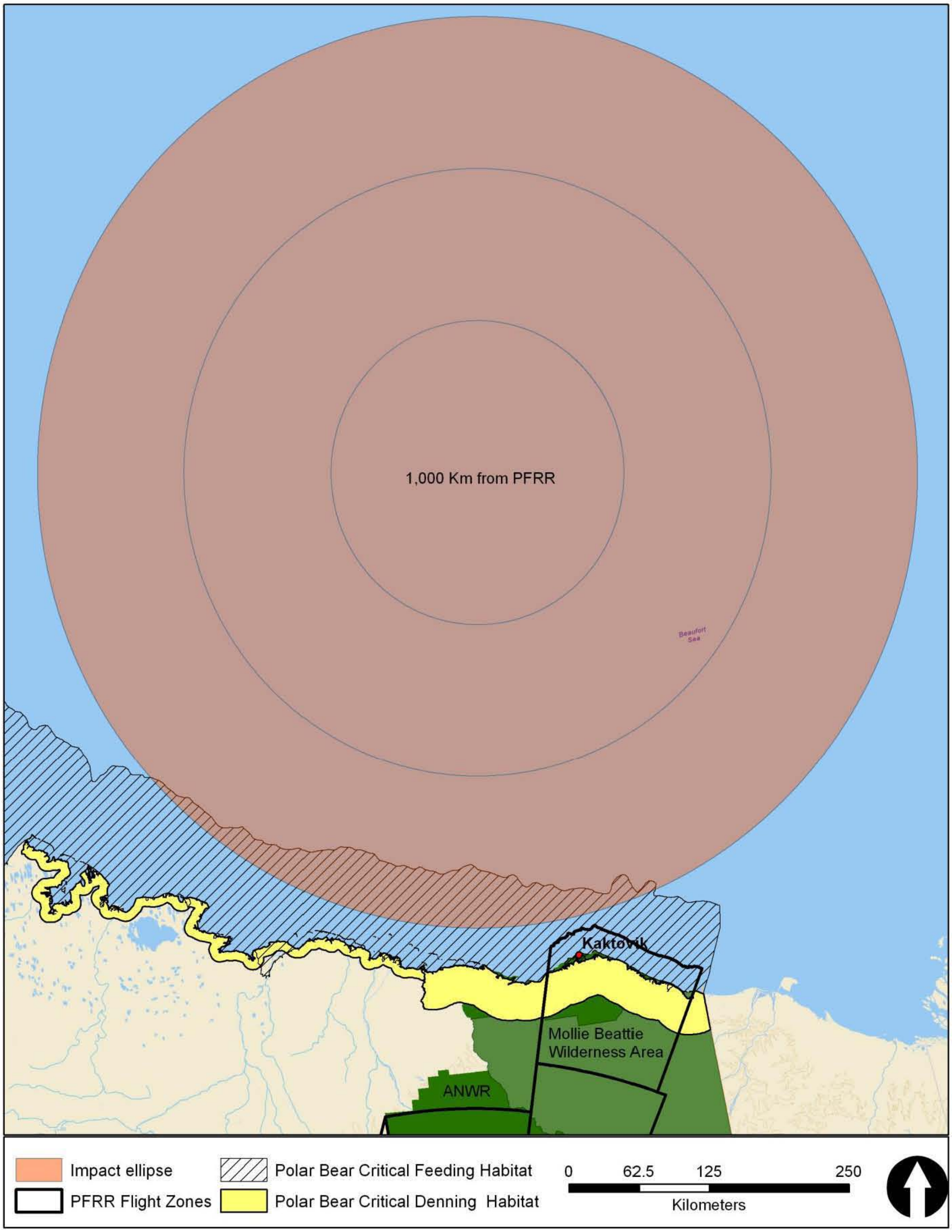
To quantify potential impacts on polar bears from the proposed alternatives, a similar probability calculation to that described for ringed seals was conducted (see Appendix G). The results are provided below in **Table 4–20**, which lists the probability that a payload or spent stage from a typical launch into the Beaufort Sea would land within polar bear critical habitat as designated by USFWS. In addition, **Figure 4–12** provides a graphic representation of the analysis presented in Table 4–20. Sounds associated with an incoming spent stage or payload is discussed in Section 4.5. Polar bears have relatively acute hearing **(Nachtigall, *et al*. 2007; Owen and Bowles 2011)**; however, the possibility that the sound of an incoming item (stage or payload) approaching the ground and hitting the ice close enough to a polar bear to affect its behavior to the scale at which take could occur is somewhat higher than for a direct hit but still very low.

Table 4–20. Likelihood of a Spent Stage or Payload Landing Within Polar Bear Critical Habitat

Distance from Poker Flat Research Range (kilometers)	Polar Bear Critical Habitat	Potential Impact Ellipse (square kilometers)	Amount of Polar Bear Critical Habitat Within Ellipse (square kilometers)	Probability of a Spent Stage or Payload Landing in Polar Bear Critical Habitat
1,000	Feeding habitat	503,000	15,000	6.6×10^{-3}
1,000	Denning habitat	503,000	0	0

Note: To convert kilometers to miles, multiply by 0.6214; square kilometers to square miles, by 0.3861.

This analysis shows that the potential for direct or indirect impact on polar bears or their critical habitat that could reach the scale at which take would occur would be so low as to be discountable, consistent with a “may affect, not likely to adversely affect” finding under the ESA and therefore insignificant.



Source: USFWS 2011j.

Figure 4–12. Likelihood of a Spent Stage or Payload Landing Within Polar Bear Critical Habitat

Payloads and spent stages that land on sea ice would be unlikely to harm a polar bear in the unlikely event that an individual polar bear were to encounter one. The item is expected to partially penetrate the ice and/or rapidly become covered by ice or drifting snow, isolating it from the environment. As the ice melts, the flight hardware would subsequently enter the marine environment, as discussed above. Any accumulation of spent stages or payloads that remained would be on the permanent sea ice approximately 400 kilometers (250 miles) from the coast and over 300 kilometers (185 miles) from the nearest designated Critical Habitat (based on information from **NSIDC [2011]**).

Effects of Sound

As with ringed seals, the primary noise-induced, disturbance-related concern would be the time following the birth of young, which generally occurs in December or early January **(Ramsay and Dunbrack 1986)**. The cubs remain in dens for several months following birth and therefore are potentially vulnerable to disturbances near dens **(Amstrup 1993)**.

As summarized under the discussion of potential effects on Ringed seals, **Blix and Lentfer (1992)** observed that only seismic testing less than 100 meters (330 feet) from a den and a helicopter taking off at a distance of 3 meters (10 feet) produced noises inside artificial dens that were notably above background levels. The authors also concluded that a polar bear in its den is unlikely to feel vibrations unless the source is very close. Supporting their findings is **Amstrup (1993)**, who also reported that polar bears residing within dens are well insulated from outside sound and vibration.

Effects of Remaining Flight Hardware

A potential concern could be injury related to flight hardware as polar bears are curious animals that typically investigate objects or smells that catch their attention **(Stirling 1988)**. Polar bears have been observed to ingest a wide range of indigestible and hazardous materials and to feed at dumps **(Clarkson and Stirling 1994)**. Instances of polar bear injury related to human-made materials (*e.g.,* pieces of a lead battery, ethylene glycol antifreeze) have been documented **(Amstrup *et al.* 1989)**. However, these have been in unnatural settings (including roadsides treated with antifreeze and dye and the Churchill, Manitoba, municipal landfill) that are much different from the habitat within the PFRR launch corridor. The dump example involved individual bears habituated to finding supplemental food in landfills **(Lunn and Stirling 1985)**.

Given the small number, wide dispersion, rapid isolation from the environment, and lack of accumulation of spent stages or payloads the likelihood of polar bears encountering and being harmed by a payload or spent stage is so low as to be discountable. Assuming four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage). As discussed earlier, payloads and spent stages that enter the marine environment would sink to the bottom and be rapidly colonized by benthic encrusting organisms and become part of the substratum. Unrecovered payloads contain materials (*e.g.,* batteries) that would result in limited and localized contamination as the materials gradually enter the aquatic environment. Considering the limited number of launches per year, the relatively small size and spatial dispersion of spent stages and payloads, and the largely inert or non-reactive nature of the items, no impacts on polar bears from these items on the ice or entering the marine environment are anticipated.

Search and Recovery

Search and recovery operations for spent stages or payloads that land in the Beaufort Sea or on sea ice would not occur and therefore would have no effect on polar bears or their critical habitat.

4.7.6.3 *Spectacled Eider*

Spectacled eider breed on the Arctic coastal plain west of the PFRR launch corridor and migrate westward and southward wintering in offshore waters in the Bering Sea. It is now considered accidental in occurrence in the PFRR launch corridor, where it would most likely be present during summer **(USFWS 2011l)**. Given its seasonal absence from the project area, it is concluded that the project would have no effect on the spectacled eider.

4.7.6.4 *Steller's Eider*

Like spectacled eider, Steller's eider breeds on the Arctic coastal plain west of the PFRR launch corridor and migrate westward and southward during the fall and winter **(USFWS 2002, 2011m)**. It is considered accidental in occurrence in the PFRR launch corridor, where it would most likely be present during summer. Given its near absence from the project area, the likelihood of any project effect is so low as to be discountable. Given its seasonal absence from the project area, it is concluded that the project would have no effect on the spectacled eider.

4.7.7 Endangered Species Act Compliance

NASA is consulting with the USFWS and NOAA Fisheries with regard to listed, proposed, and candidate species under their respective jurisdictions. USFWS generally has authority over terrestrial and aquatic plant, fish, and wildlife species onshore. USFWS's jurisdiction includes polar bear and its critical habitat, spectacled eider, and Steller's eider, and would include yellow-billed loon, if the species is proposed for listing. NOAA Fisheries' jurisdiction includes marine and anadromous species, including marine mammals.

NASA has exchanged initial correspondence with both agencies (see Appendix A) and has discussed the project, the proposed analysis, and concerns during several conference calls with agency representatives. Additionally, a Biological Assessment (BA) has been submitted to each agency, documenting the results of the analysis conducted for this *PFRR EIS* with regard to the listed, proposed, and candidate species under their jurisdiction (see Appendix H). **Table 4–21** below summarizes the ESA covered species and NASA's effects determinations. USFWS concurred with NASA's assessment; a response from NOAA Fisheries is pending.

Table 4–21. Summary of Endangered Species Act Determinations for Listed, Proposed, and Candidate Species Potentially Occurring Within PFRR Flight Corridor

Species	ESA Status	Agency with ESA Jurisdiction	NASA ESA Determination	Agency Concurrence
Polar bear	Threatened	USFWS	May affect, not likely to adversely affect	Yes
Polar bear critical habitat	Designated	USFWS	May affect, not likely to adversely affect	Yes
Bowhead whale	Endangered	NOAA Fisheries	No effect (seasonal absence)	Pending
Ringed seal	Proposed threatened	NOAA Fisheries	Not likely to jeopardize continued existence	Pending
Bearded seal	Proposed endangered	NOAA Fisheries	No effect (seasonal absence)	Pending
Spectacled eider	Threatened	USFWS	No effect (seasonal absence)	Yes
Steller's eider	Threatened	USFWS	No effect (seasonal absence)	Yes
Yellow-billed loon	Candidate	USFWS	No effect (seasonal absence)	Yes

Key: ESA=Endangered Species Act; NASA=National Aeronautics and Space Administration; NOAA=National Oceanic and Atmospheric Administration; PFRR=Poker Flat Research Range; *PFRR EIS=Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range*; USFWS=U.S. Fish and Wildlife Service.

4.7.8 Summer Launches

This section briefly considers potential impacts that would need to be considered in the event that summertime launches are proposed. Additional environmental review and regulatory compliance, including ESA consultation, would be conducted by NASA in the event a summer launch is proposed.

4.7.8.1 *Vegetation*

In the event of a summertime launch (May to September), more vegetation would be exposed due to a lack of snow cover, and a higher degree of impact would occur. Within the immediate area of the impact point, it is assumed that individual plants would be crushed, uprooted, or otherwise disturbed in a manner that could potentially result in the temporary loss of vegetation. Retrieval of the payload or spent stage would affect an unknown but localized area of vegetation as discussed in Section 4.7.3 since these activities are proposed to be carried out during the summer under any launch scenario. Regrowth of vegetation would be rapid from resprouting and natural reseeding from nearby plants, given the small area of disturbance and the short-term duration of activities at the site. Given the very small area affected by impact and recovery activities, and the potential recovery of the habitat, adverse impacts from launch and recovery activities would be short-term and negligible.

4.7.8.2 *Wildlife*

During summer months (May through September), migratory avian species that are absent during winter return to the project area and engage courtship, nesting, and young rearing activities. Species that hibernate or are otherwise dormant during winter become active. Grazing and browsing animals are able to take advantage of the abundant new growth stimulated by increasing daylight periods and warmer temperatures and may be moving from winter ranges to summer range. For example, the Central Arctic Caribou Herd moves to summer range outside PFRR from wintering grounds that include the northwestern part of PFRR, whereas the Porcupine Caribou Herd tends to concentrate in the northern part of PFRR and along the coast in Canada during the summer and spends the winter months south of the Brooks Range and in the Richardson and Ogilvie Mountains of the Yukon Territory **(USFWS 2011c)**. Many species are more sensitive during the summer or non-winter months, especially when nesting or bearing young, than during other parts of their life cycle. During summer, spent stages and payloads would have greater potential to land in proximity to wildlife than during winter because of the greater number of species present, potentially causing short-term behavioral response such as flight. Responses to search and recovery activities would be negligible as described in Section 4.7.4, since these activities would normally occur during summer under any launch scenario.

4.7.8.3 *Fisheries Management Plans, Essential Fish Habitat, and Subsistence Fisheries*

Payloads and spent stages are more likely to go directly into freshwater or marine environments during the summer rather than landing on ice during winter and subsequently entering the aquatic environment at breakup. The likelihood of direct impacts on fish of importance for subsistence or commerce fisheries is minimal. Payloads and spent stages would be colonized by encrusting marine organisms and become part of the habitat. Under normal conditions, the spent stages are essentially inert aluminum tubes after short periods of exposure to water (see Section 4.3). Unrecovered payloads would contain materials such as constituents of batteries that would gradually enter the aquatic environment resulting in limited and localized contamination that would be rapidly diluted by currents as described in Section 4.7.5. Considering the limited number of launches per year (an average of four) and the small size and geographic dispersion of spent stages and payloads, any direct and indirect adverse impacts would be minor and short-term in duration for all alternatives. Therefore, the project would not adversely affect EFH, target species, or subsistence species.

4.7.8.4 *Endangered, Threatened, and Special Status Species*

In the event of a summertime launch (May to September), further environmental review would be conducted regarding the potential impacts on federally and state-listed threatened and endangered species, as well as those listed by BLM. The additional review would need to take into account the possibility of status changes of species that are currently proposed or candidates for listing as threatened or endangered, or BLM-listed, as well as an analysis of species' lifecycle activities, which could result in different impacts on listed species such as ringed seals and polar bears. For example, ringed seal populations tend to follow the ice edge northward as it retreats during the summer months, leading to a more widespread and dispersed population distribution. Therefore, since more occupied habitat could fall within the potential impact area, there is a greater chance that a payload or spent stage could land within an area of summertime ringed seal concentration.

Potential for impacts on other ESA species, including the bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate), which are summer residents and absent from the ROI during the winter, would have to be considered. Additionally, spectacled eiders and Steller's eiders, both threatened species that are accidental in occurrence and uncommon within the ROI, would need to be addressed because they would most likely be present only during the summer, if they were present at all.

4.8 LAND USE AND RECREATION

This section describes potential impacts on land use and recreation within and adjacent to PFRR and its launch corridor.

4.8.1 Methodology

Analysis of land use and recreation includes the land within the PFRR launch corridor (the ROI), pertinent land use plans and regulations, and land ownership and availability. The probability of landing on a particular property of interest, the amount of land disturbed, and conformity with existing land use were considered to evaluate potential impacts. Composite probabilities of impact are summarized from Appendix G. In addition, given the level of public interest in Wilderness Areas (*i.e.,* Mollie Beattie, Yukon Flats recommended area) within the PFRR launch corridor, specific missions from the past 10 years were also analyzed to determine the range of probabilities and demonstrate what is considered typical versus an occasional outlier mission that had a higher probability of landing within the area.

Land use impacts could be adverse if they resulted in some level of degradation, or impairment of the land or beneficial if they resulted in an increased ability to use the land potentially impacted. The context of the impacts would be global if the impact would have worldwide implications; regional if the impact would affect an entire area such as the entire PFRR ROI; and localized if the impact would affect a subset of the PFRR ROI such as the Arctic NWR but not the remainder of the ROI. The intensity of an impact to land use would be considered major if a component of an alternative were inconsistent with an existing land use plan or special use permit or memorandum of agreement. A moderate impact would result in a change in land use; however, the change would be consistent with an existing land use plan or special use permit or memorandum of agreement. A minor to negligible impact would result when there would be little to no change to land use, and all actions would be consistent with existing land use plans, special use permits, or memoranda of agreement. Regarding duration, a land use impact would be considered long-term if the effect lasted longer than 5 years, as could be the case in a right-of-way permit or easement; medium-term if the effect lasted from 1–5 years; and short-term if the change were to persist for 1 year or less, as is the case with annual special-use permits.

Recreation impacts include the potential limitation of those activities due to the launch and recovery of NASA sounding rockets launched from PFRR. Recreation impacts could be adverse if they resulted in some level of degradation or impairment of recreational opportunities or beneficial if they resulted in increased recreational opportunities. The context of the impacts would be global if the impact would have worldwide implications; regional if the impact would affect an entire area such as the entire PFRR ROI; and localized if the impact would affect a subset of the PFRR ROI such as the Arctic NWR but not the remainder of the ROI. The intensity of an impact on recreation would be considered major if a recreational use were permanently displaced due to the implementation of a component of an alternative. A moderate impact would result if a recreational use were to be displaced or halted for up to one season of use; however, the use would be expected to resume the following year. A minor impact would result when a recreational use were to be displaced for up to several weeks. A negligible impact would occur when a recreational use were to be only displaced or required to cease for no more than 1 week. Regarding duration, an impact would be considered long-term if the effect occurred on a regular basis (*i.e.,* annually), medium-term if the effect only occurred occasionally (*i.e.,* semi-annually or less), and short-term if the change were to rarely occur.

4.8.2 No Action Alternative

Table 4–22 shows the typical stage and payload impact locations within the PFRR launch corridor for up to eight launches per year that could occur under the No Action Alternative. It is expected that launches would average four per year over the next 10 years. NASA would continue to avoid launching sounding rockets with predicted impact points in the Mollie Beattie Wilderness Area.

Table 4–22. Typical Payload and Stage Impact Points

	Predicted Payload Impact Points		Predicted Stage Impact Points	
Launches Per Year	**Number of Payloads**	**Location of Impact**	**Number of Stages**	**Location of Impact**
4 (up to 2 Black Brant XII and 2 Terrier-Improved Orion)	2	Arctic Ocean	2	Arctic Ocean
	2	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands	2	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
			2	Yukon Flats NWR
			2	White Mountains NRA
			4	Poker Flat North and South Special Use Areas
8 (up to 4 BB XII and 4 T-IO or Terrier-Improved Orion)	4	Arctic Ocean	4	Arctic Ocean
	4	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands	4	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
			4	Yukon Flats NWR
			4	White Mountains NRA
			8	Poker Flat North and South Special Use Areas

Key: NRA=National Recreation Area; NWR=National Wildlife Refuge.

4.8.2.1 *Land Use*

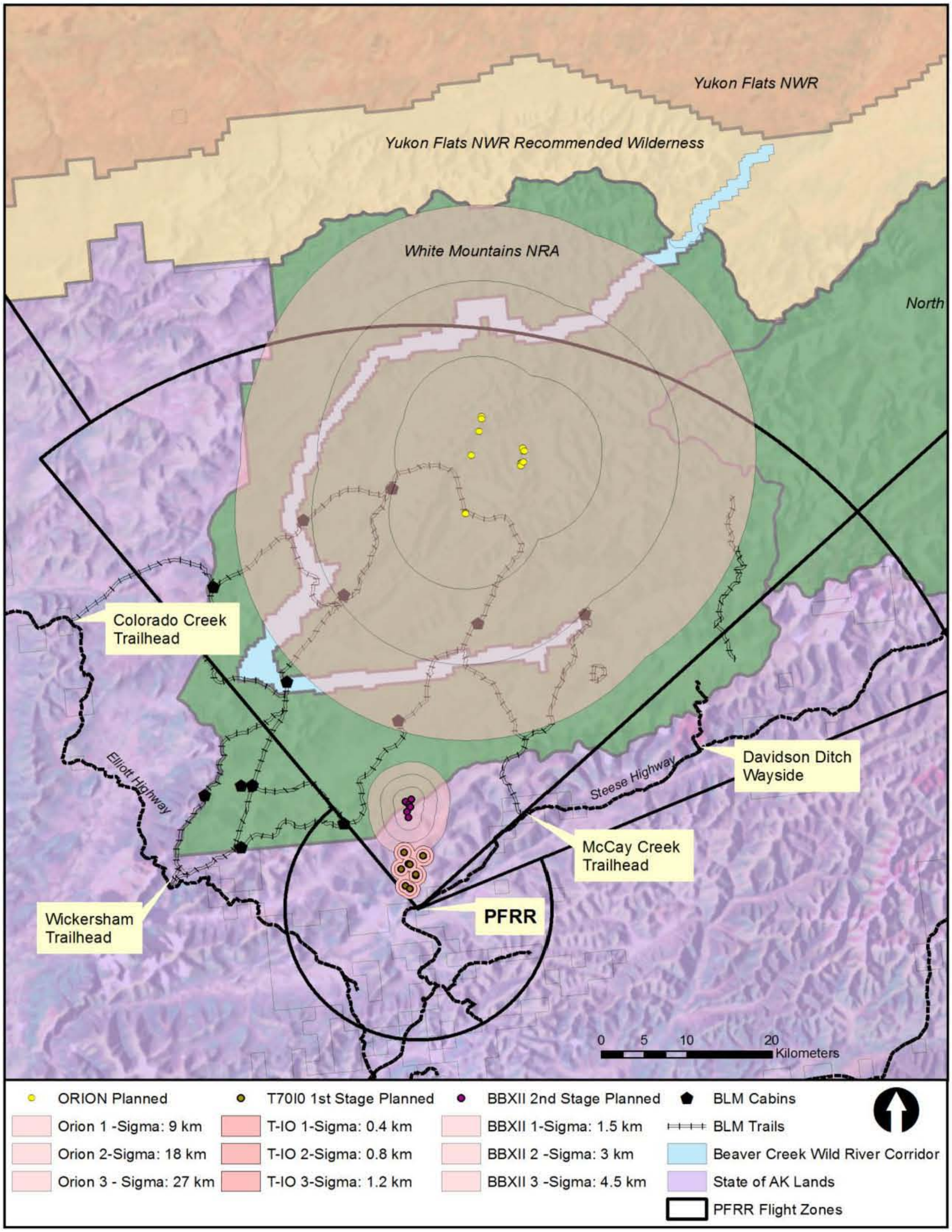
Continued launches by the NASA SRP from PFRR under the No Action Alternative would require authorization from downrange landowners, including USFWS, BLM, the State of Alaska, and the Native Village of Venetie Tribal Government (see Appendix C).

BLM Lands

An evaluation of past flights depicted in **Figure 4–13** indicates that the area most likely impacted would be the southern and central portions of the White Mountains NRA. The initial stages of vehicles most currently flown, the T-IO and BB-class rockets, land well south of most recreational trails and outside of the Wild River corridor. In relative terms, the single-stage Orion vehicle, with its larger dispersion, has the highest probability of landing within the wild river corridor (approximately 1 in 14, or 7 percent chance) or areas frequented by recreational users (*e.g.,* trails and cabins). Of the most commonly used vehicles, the second stage and payload of the T-IO, which would most likely land within Yukon Flats NWR, would have the greatest potential for landing within the Wild River corridor; however, it would be very small. Based upon the southernmost predicted landing point within the past 10 years dataset, the probability is approximately 1 in 1,000, or 0.1 percent. Although possible, it is unlikely that spent stages would land in the north portion of the Steese National Conservation Area (NCA).

In general, the overflight, landing, and recovery of sounding rocket would be in contrast to the natural and recreation-based land uses of the properties. However, in consideration of the infrequency of use, the time of year that operations occur, and the heritage of the program at PFRR (that pre-dates the Alaska National Interest Lands Conservation Act [ANILCA]), the No Action Alternative could continue to be permitted through the BLM 2920 Permit process provided that the lands are not significantly impaired.

To ensure that its operations do not significantly impair the lands, NASA and UAF would continue to follow all terms and conditions of future authorizations issued by BLM. According to the terms and conditions of the most recent land use permit **(USDOI 2011a)**; UAF is required to conduct all recovery activities in a manner that ensures little impact on the physical and biological characteristics of the BLM lands. Details of these conditions are contained within Appendix F.



Key: km=kilometers; NRA=National Recreation Area; NWR=National Wildlife Refuge; PFRR=Poker Flat Research Range.

Figure 4–13. Typical Landing Locations Within U.S. Bureau of Land Management Lands

USFWS Lands

An evaluation of the past 10 years' flights depicted in Figure 4–13 indicates that the area most likely impacted would be the central and western portions (west of Venetie lands) of the Yukon Flats and Arctic NWRs. Moderate-range rockets, including the T-IO and single-stage BB (BB V), could either land on Yukon Flats or Arctic NWR, depending on mission requirements. The longest-range rockets (BBs IX–XII) would typically land in Arctic NWR.

No missions would have planned impacts within Mollie Beattie Wilderness Area. However, the probability cannot be totally discounted. In general, the T-IO, the single-stage Brant, and BBs IX and XII could present the possibility of landing within the Wilderness Area. An analysis of the past 10 years' missions indicates that the second stage of a single T-IO flight had a probability of about 1 in 5, or 20 percent chance, of landing within the Mollie Beattie Wilderness Area. All other flights of this vehicle had 3-sigma dispersions that did not overlap the Wilderness Area; the next highest probability for a flight in the past 10 years was substantially lower, at about 1 in 8,100. The greatest probability for a BB V was calculated to be approximately 2.5 percent, or 1 in 40. All other flights of this vehicle had planned impact locations well away from the Mollie Beattie Wilderness Area, resulting in landing probabilities of approximately 1 in 3 million. The highest probability of impact from a single BB IX second stage was about 44 percent, or 1 in 2.5. All other flights were substantially lower, with the highest of them being about 1 chance in 212,000. The greatest estimated probability for the third stage of the BB XII, which typically lands west of Arctic Village, was approximately 1 in 40, or a 2.5 percent chance. In general, the probability of BB XII flights landing within Mollie Beattie Wilderness may vary between approximately 1 in 200 (0.5 percent chance) and 1 in 500 (0.2 percent chance); however, planned landing locations cannot fluctuate as greatly as the other sounding rockets due to mandatory standoff distances between Arctic Village to the east and the range boundaries to the west.

For all recently flown rocket configurations, only the single-stage Orion and the T-IO have had 3-sigma dispersions that overlap the recommended Wilderness Area within Yukon Flats NWR. The probability of the single T-IO flight landing within the recommended area was 1 in 18, or 5.5 percent; the greatest Orion probability was 1 in 250, or 0.4 percent. All other stages and payloads were well outside (greater than 3-sigma distance) of this area.

Regarding designated Wild Rivers within the USFWS lands, probabilities of longer-range motors or stages landing within the Wind River vary dramatically depending on launch vehicle (see Table 4–38 in Section 4.15.8 for complete data). In general, the vehicle with the most consistent probability of landing within the Wind River corridor is the BB XII, with its probability ranging from between 1 in 14 (7 percent) and 1 in 28 (3.5 percent). The general range of probabilities of landing within the Ivishak River corridor also vary greatly among vehicles, with the BB XII the most consistent between approximately 1 in 10 (10 percent) and 1 in 45 (2.5 percent) While some missions of BB IX and T-IO would have probabilities of approximately 1 in 50 (2 percent) of landing within the Sheenjek, the vast majority of missions would be substantially lower.

In general, the overflight, landing, and recovery of sounding rockets would be compatible with the natural and wildlife-dependent uses of the lands, because USFWS has the ability to authorize the conduct of scientific research, such as that enabled by launches from PFRR, in its refuges. The most recent USFWS-issued permits for rocket landing and recovery within the Yukon Flats and Arctic NWRs require the recovery of flight hardware. Therefore, the No Action Alternative, which would direct recovery of payloads solely for scientific need, would not be consistent with the terms and conditions of the use permits.

State of Alaska Lands

With the exception of the longer-flying single-stage rockets (*e.g.,* Orion, BB V), all first stages and a limited number of second stages would land within the state property (identified as Poker Flat North and South Special Use Areas) just north of the PFRR launch site. The ADNR Poker Flat North and South Special Use Areas are designated as lands where rocket and rocket booster impacts are allowed without further authorization **(ADNR 1990a, 1990b)**. It is noteworthy that the 10,400-hectare (25,700-acre) Caribou-Poker Creeks Research Watershed (CPCRW) is within the state-owned property just north of Steese Highway. Jointly owned by the State of Alaska and UAF, the watershed is reserved for ecological, hydrological, and climatic research. As a result, several miles of gravel roads, bridges, and various hydrologic measurement devices are located within the property, including flumes, water level recorders, and large-capacity rain gauges. In consideration of minimizing potential interruption of the research efforts within this site, PFRR historically has not undertaken land-disturbing recovery efforts, a practice which would continue under the No Action Alternative. Prior to entry into the area (*e.g.,* in the case of a failed flight recovery), PFRR staff would coordinate with CPCRW site managers. Therefore, operations under the No Action Alternative would be consistent with the existing land use.

The use permit between UAF and the ADNR for other state-owned lands within the flight corridor **(ADNR 2009)** allows UAF to continue researching and collecting flight hardware and provides a payload safety area near the PFRR launch site. The permit requires that the ADNR-managed lands within the ROI included in the permit be maintained in a neat, clean, and safe condition, free of any solid waste, debris, or litter. All holes created as a result of the activities authorized under the permit are required to be backfilled. Limited recovery of spent payloads and rocket stages under the No Action Alternative would not be fully consistent with this designation.

Tribal Lands

Based upon the composite analysis of historic impact locations, the probability of a stage or payload landing within Venetie lands can vary greatly, ranging from approximately 1 in 2,700 to 87 percent (see Appendix G). The memorandum of agreement between UAF and the Native Village of Venetie Tribal Government **(Venetie 1989)** includes the requirement for UAF to remove, within a reasonable time, any portions of rocket vehicles or payloads found within the Venetie lands. Additionally, UAF provides compensation for the use of these lands when the probability of landing within the Venetie property is greater than 1 in 100. Under the No Action Alternative, NASA and UAF would continue these practices, and would therefore be consistent with the designated land uses for the area.

Future missions could require the use of lands owned and/or managed by other tribal entities, including villages or regional corporations. The composite analysis of landing within Doyon, Limited, lands shows that probabilities are relatively low for typical missions, ranging from approximately 1 in 250 up to approximately 1 in 125. Although there are no active agreements with such entities, NASA and UAF would ensure that future sounding rocket launches with planned impacts on other landowners' properties are consistent with their designated land uses and that all conditions of use were satisfactory to the owner prior to the launch and/or recovery effort.

Summary of Impacts

Land use impacts from launches would be considered adverse, localized, negligible, and short-term in duration. The continued launch of NASA sounding rockets from PFRR would be consistent with existing permits and agreements between UAF and the land managers within the ROI (see Appendix C). However, land use impacts as a result of remaining flight hardware and limited recovery efforts under the No Action Alternative have the potential to be major. The removal of all new and existing flight hardware with known locations from USFWS- and BLM-managed lands is required as part of the permit requirements. The removal of only a small number of payloads or spent stages, as requested by scientists, as is expected to occur under the No Action Alternative, would not be consistent with existing land use permits. The impacts associated with leaving these payloads and spent stages where they landed have the potential to be regional, affecting multiple areas within the PFRR ROI; major to minor in intensity, depending on where the item is located; and long-term in duration, depending on how long the unrecovered payloads or spent stages remain on downrange lands.

Because limited recovery activities under the No Action Alternative are anticipated within designated Wild River corridors or Wilderness Areas, no direct land use impacts (*e.g.,* aircraft overflight) are anticipated from recovery operations in these areas. However, it is possible for payloads or spent stages to land within the Mollie Beattie Wilderness Area and within designated Wild River corridors. If NASA or UAF were apprised of the location a piece of flight hardware, they would consult with the respective landowner (*i.e.,* BLM or USFWS) to determine the appropriate course of action for conducting a removal operation. Given the sensitivities of these areas, a case-specific analysis would be conducted to determine the least intrusive practicable option for removing the hardware. It is highly likely that any temporary effects of the removal activity would be far less than leaving the visible piece of flight hardware within the special use area.

4.8.2.2 *Recreation*

The launches would occur during the winter months, *i.e.,* October through April, with the possibility of an occasional launch during the summer or non-winter months, *i.e.,* May through September. A wide variety of recreational activities occur during both seasons. Impacts on recreational activities within the ROI would be considered adverse, regional, negligible in intensity, and short-term in duration.

BLM Lands

Areas and Times of Greatest Use – Winter recreational use (*e.g.,* skiing, snowmobiling, dog sledding) of the subject BLM lands is generally expected to be greatest around the cabin and trail system within the White Mountains NRA (see Figure 4–13). Summer use (*e.g.,* hiking, rafting, and camping) in the White Mountains NRA tends to focus on three areas, including Wickersham Dome, Nome Creek (including Cripple Creek Campground and Quartz Creek Trail), and Beaver Creek. Most of the recreational opportunities (*e.g.,* hiking, fishing, and hunting) in the Steese

NCA occur during non-winter months, with fall big game hunting attracting the greatest number of visitors **(USDOI 2012a)**.

Impacts – Activities under the No Action Alternative would not limit the ability of users to visit or take part in recreational activities within White Mountains NRA or Steese NCA. According to the terms and conditions of the land use permit with the Eastern Interior Field Office of BLM **(USDOI 2011a)**, UAF is required to post notices of planned launches to alert visitors of the launches at the following trailheads within BLM lands:

- Wickersham Dome Trailhead
- Colorado Creek Trailhead
- McKay Creek Trailhead
- Davidson Ditch Wayside

It is possible that winter visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from several days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term. Visitors that opted to enter the area could witness or hear the impact of a spent stage landing in the area. However, since most of the launches are expected to take place in the winter and largely at night, it is unlikely that this would occur. For launches that would cross over White Mountains NRA or Steese NCA, NASA considers the potential of impacting public cabins, and due to safety considerations could be required to delay launch operations until the cabins have been vacated.

As shown on Figure 4–13, the most commonly used rockets would not be expected to have hardware land within areas of highest recreation use, including those that contain public trails and cabins. In the past 10 years, only the single-stage Orion has had a 3-sigma dispersion that overlaps these areas. The higher-performing vehicles, including the T-IO and BB-class vehicles, have stages that land either south or well north of these recreational features.

In the case that a piece of flight hardware were encountered by a recreational user, it is expected that impacts would be greatest on those persons visiting the area for solitude and primitive types of recreation, including hiking, camping, and non-motorized boating. Potential effects would be visitor-specific; however, it is possible that encountering a human-made object could negatively affect a person or group's wilderness experience. Those recreational users of the BLM lands for the purposes of off-highway vehicle use and hunting would be expected to be the most tolerant of encountering these items.

Because no payloads or spent stages are expected to be recovered from the White Mountains NRA or Steese NCA under the No Action Alternative, no impacts associated with search and recovery operations on recreational opportunities are expected in these areas under this alternative.

USFWS Lands

Areas and Times of Greatest Use – Most people visit Arctic NWR and Yukon Flats NWR during the summer in June, July, August, and September **(USFWS 2008b, 2011c)**. Winter recreational uses within Yukon Flats NWR typically are primarily skiing, trapping, and snowmobiling, and expected to be very limited and dispersed. Activities are likely greatest near permitted cabins (used primarily for trapping) and toward the south, adjacent to the White Mountains NRA. Most non-winter recreation is associated with river float trips coupled with hunting; the majority of these activities are expected to occur on Beaver Creek and the Yukon River **(USFWS 2010a)**.

Within Arctic NWR, winter recreational uses may include camping and snowmobiling, with these activities likely to be most prevalent along the western portion of the Arctic NWR due to the presence of several villages and the Dalton Highway **(USFWS 2011c)**. During non-winter months, the most frequent recreational uses are river floating, hiking and backpacking, and hunting **(USFWS 2011c)**. Recreational users who are not commercially guided are thought to concentrate in the Atigun Gorge area **(Reed and St. Martin 2009)**. Commercially supported recreational use is greatest north of the Brooks Range, with this area hosting more than 75 percent of the Arctic NWR's visitors. The most popular areas visited (in order of most visited) are the Kongakut River drainage, Hulahula River, Marsh Fork-Canning River, Jago River, and the main stem of the Canning River. South of the Brooks Range, the Sheenjek and Coleen Rivers are most commonly visited **(USFWS 2011c)**.

Impacts – Launches under the No Action Alternative would not limit the ability of users to visit or take part in recreational activities within Arctic NWR or Yukon Flats NWR. It is possible that visitors to either NWR could witness or hear a launch or the impact of a spent stage landing in the area. However, since most of the launches are expected to take place in the winter, when the numbers of visitors to these areas are very low, it is unlikely that this would occur.

Discovery of spent stages or payloads from past launches within either Yukon Flats or Arctic NWR is also possible while people are participating in recreational activities. Within Yukon Flats NWR, of the two areas of greatest use, recreational users of the Yukon River would have a higher likelihood of encountering a piece of flight hardware. Of the vehicles currently flown, the T-IO and BB V would have the greatest likelihood of landing near the Yukon River; however, given the small subset of these flights in the past 10 years with dispersions overlapping the river corridor, the chance of this occurring in the future (and someone then encountering the item) would be very low.

Within Arctic NWR, users of the areas of highest commercially assisted recreational use north of the Brooks Range (*i.e.*, Kongakut and Hulahula Rivers) would not likely encounter any flight hardware. The most likely vehicles to fly a trajectory that could possibly result in flight hardware landing within these areas would be the BBs IX and XII. However, based upon the past 10 years of flight data, neither mission had a 3-sigma dispersion that overlapped these areas. The Jago River would be even more unlikely to be affected by flight hardware given its easterly location. In relative terms, flight hardware would be most likely to land within the Canning River and its Marsh Fork and would most likely include third stages of BB XIIs and to a lesser extent, second stages and payloads of BB IXs and T-IOs. To provide perspective, the approximate probability of landing the single closest BB XII flight in the past 10 years within the Marsh Fork was approximately 1 in 190 (assuming a corridor width of 1.6 kilometers [1 mile]). The chance of landing within the main stem of the Canning River would be even less.

South of the Brooks Range, trajectories of the T-IO, BB V, and BB IX with planned impact locations east of the East Fork of the Chandalar River could affect the Sheenjek and to a lesser extent, the Coleen River corridors. The highest probability mission for landing within the Sheenjek over the past 10 years for each of these three vehicles was similar, approximately 1 in 50 (assuming a corridor width of 1.6 kilometers [1 mile]) for a single mission. All other missions were approximately 1 in 500 (0.2 percent chance) or greater; therefore, the potential for future impacts is assumed equally remote. The Coleen River is outside of the range boundaries; therefore, landing within it would be highly unlikely.

In the case that recreational users of the NWRs were to discover a piece of flight hardware, it could negatively affect their experience, particularly those persons intending to have a wilderness experience. Others may find it a positive experience to discover a spent stage or payload. It is expected that those persons engaged in hiking and rafting would be the most sensitive to finding sounding rocket hardware, with hunters, trappers, and snow machines the most tolerant. The impact would be on a person-by-person basis and would be influenced by the perception of the individual.

UAF and NASA would only recover payloads and spent stages if desired for scientific reasons; therefore, these search and recovery activities would most likely take place immediately following a launch (*i.e.*, winter). During recovery operations, persons taking part in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to a nearby landing area to pick up a recovered payload that has been dropped there by a helicopter. The impacts associated with these activities would be similar to those associated with planes dropping visitors off at various landing spots throughout Arctic NWR and Yukon Flats NWR. Impacts from recovery activities would be considered adverse and localized. However, because they would be limited to a very small area where the recovery activities were taking place, they would be considered negligible in intensity and short-term in duration.

4.8.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, UAF and NASA would attempt to recover new payloads and new spent and existing spent stages, if practicable. **Table 4–23** below lists the number of payloads and new and existing spent stages that would be recovered if found and the potential recovery locations under Alternative 1. Under Alternative 1, it is estimated that 1 additional payload and 10 additional stage recoveries would be attempted annually compared to the No Action Alternative.

Table 4–23. Alternative 1 Projected Recovery Operations

Payloads	New Spent Stages	Existing Spent Stages	Total Recoveries	Potential Location of Recovery
0	2	1	2–3	Wind River Area of Arctic NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
2	2	0	2–4	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
0	2	1	2–3	White Mountains NRA
0	0	2	2	ADNR Land

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Recovery activities under Alternative 1 are expected to include removal of spent stages that have been identified near the federally designated Wild River corridor of the Wind River.

4.8.3.1 *Land Use*

Land use impacts from launches under Alternative 1 would be consistent with the impacts listed for the No Action Alternative in Section 4.8.1 and would be continue to be considered adverse, localized, negligible in intensity, and short-term in duration. Recovery of payloads and new and existing spent stages under Alternative 1 would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with BLM, and USFWS, and landowners within the ROI. The attempted recovery of all new payloads and on-land spent stages would be consistent with the Federal special land use permits, which require these efforts. Known components from previous launches would be recovered as they are identified. The adverse impacts associated with search and recovery operations would be localized, minor in intensity, and short-term in duration. It is expected that in most cases, the long-term impacts of leaving a piece of flight hardware within the downrange lands would be greater than the short-term disturbances (*e.g.,* noise, aircraft overflight) associated with recovery. However, NASA and UAF would consult with the respective landowner in making this case-by-case determination. Therefore, it is possible that while some stages could be left in downrange lands, it would only be done so if determined to be in the best interest of the lands and how they are used (*e.g.,* preservation of fish and wildlife habitat, recreational values).

Alternative 1 would also be consistent with the ADNR special use designation of the Poker Flat North and South Special Use Areas. As recovery of items would most likely apply to historic stages, it is expected that impacts on the CPCRW data collection efforts would be minimal, as only those identified or requested by site staff would be removed. Any recoveries deemed to be more damaging than beneficial to the site would be left in place.

No predicted impact points would be targeted within Mollie Beattie Wilderness Area; however, it is possible for payloads or spent stages to land within the wilderness area. In the unlikely event this was to occur, NASA and UAF would work with USFWS to determine if and how the rocket components should be recovered. It is expected that a case-specific assessment would be performed to determine the least intrusive practicable option for removing the flight hardware. Recovery of spent stages within designated Wild River corridors would be conducted in a manner to limit disturbance to the wide variety of vegetation, scenery, and wildlife characteristics of the corridors, should they land there.

4.8.3.2 *Recreation*

Impacts on recreation would be consistent with the impacts listed for the No Action Alternative in Section 4.8.2.2. Activities under Alternative 1 would not limit the ability of users to visit or take part in recreational activities within White Mountains NRA, Steese NCA, Arctic NWR, Yukon Flats NWR, or other areas within the ROI. As described under the No Action Alternative, UAF and NASA would post notices of planned launches to alert visitors at required trailheads, as well as in local newspapers. It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term.

Recovery activities under Alternative 1 would remove payloads and new and existing spent stages in an environmentally friendly manner where practicable. The removal of these additional components, beyond those that would be removed under the No Action Alternative, would reduce the likelihood that future visitors would discover payloads or spent stages during their visits to these areas.

Increased impacts associated with search and recovery operations on recreational opportunities are expected under Alternative 1 compared to the No Action Alternative. Initial search activities would have negligible, short-term impacts on persons participating in recreational activities in areas within the PFRR launch corridors because most of these activities would take place in the winter months, when there are few visitors. Recovery operations would be limited to a small number of days during the summer, when helicopters would be recovering payloads or spent stages under Alternative 1. These activities are estimated to last up to 10 days annually and spread across downrange lands.

As discussed in Section 4.8.2.2, during recovery operations, persons participating in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to pick up a recovered payload. This would be especially true within the northern parts of the Arctic NWR, which often have open and treeless riparian areas, allowing recreational visitors to observe the presence of other activities over long distances **(USFWS 2011c)**.

In general, the impacts associated with these activities would be similar to those associated with aircraft dropping visitors off at various landing spots throughout the downrange lands. However, for some visitors, especially for those seeking a wilderness experience, these impacts could be more acute. This could be especially true within Arctic NWR, where helicopters are a generally prohibited activity with the exception of several special use permit holders, one of those being UAF. Therefore, the perceived disturbance of helicopter use on recreational users could again be amplified. However, given the relative infrequency of flights and the very low probability that a low-flying/landing recovery action would be necessary within the most highly used river corridors within the downrange lands, adverse effects are anticipated to be localized, minor in intensity, and short-term in duration.

4.8.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, UAF and NASA would attempt to recover payloads and new and existing spent stages, as presented in **Table 4–24**, to the maximum extent practicable. Under Alternative 2, two additional payloads and 6 additional stages are projected for attempted recovered annually compared to Alternative 1, and three additional payloads and 16 additional stages are projected for attempted recovery compared to the No Action Alternative.

Table 4–24. Alternative 2 Projected Recovery Operations

Payloads	New Spent Stages	Existing Spent Stages	Total Recoveries	Potential Location of Recovery
0	2	2	3–4	Wind River Area of Arctic NWR
4	2	2	5–8	Yukon Flats NWR or Venetie Indian Corporation and Neets'ai Corporation Lands
0	2	2	2–4	White Mountains NRA
0	2	2	4	ADNR Land

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

4.8.4.1 *Land Use*

Land use impacts from launches under Alternative 2 would be consistent with the impacts listed for the No Action Alternative in Section 4.8.1.3. Recovery of the additional payloads and new and existing spent stages listed in Table 4–24 would further assist UAF in complying with the requirements of the special use permits and memoranda of agreement with the landowners within the ROI. The impact on these areas would be adverse, localized, minor in intensity, and short-term to long-term in duration, depending on how long the known payloads and spent stages remain within the launch corridor. However, it is possible that additional efforts would be made to remove any visible signs of flight hardware. Accordingly, larger clearing of areas or greater excavations could be required. This could result in longer-term impacts and could be inconsistent with existing land use permits, all of which currently stipulate that clearing and digging must be kept to a minimum.

Similar to the No Action Alternative and Alternative 1, Alternative 2 would be consistent with the ADNR special use designation of the Poker Flat North and South Special Use Areas. However, it should be noted that under this alternative some removal of new stages would occur. Therefore, it would be necessary to coordinate with the CPCRW staff to minimize the potential effects on the long-term hydrologic data collection efforts at the site. It is possible that recovery efforts could introduce additional disturbances (*e.g.,* ruts) to the area, which could adversely affect the quality of the data collected, which is intended to be done within an otherwise undisturbed context.

No predicted impact points would be targeted within Mollie Beattie Wilderness Area; however, it is possible for payloads or spent stages to land within the wilderness area. In the unlikely event this was to occur, NASA and UAF would work with USFWS to determine the minimum requirements for how the rocket components should be recovered. Recovery of spent stages within any of the designated Wild River corridors within the PFRR would be conducted in a manner to limit disturbance to the wide variety of vegetation, scenery, and wildlife characteristics of the corridors, should this occur.

4.8.4.2 *Recreation*

Impacts on recreation would be consistent with the impacts listed for the No Action Alternative in Section 4.8.2.2. Activities under Alternative 2 would not limit the ability for users to visit or take part in recreational activities within White Mountains NRA, Steese NCA, Arctic NWR, Yukon Flats NWR, or other areas within the ROI. UAF would continue to meet the requirements of the special land use permits for the federally managed lands within the ROI. UAF would post notices of planned launches to alert visitors at required trailheads, as well as in local newspapers. It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. These impacts would be negligible and short-term.

Recovery activities under Alternative 2 would remove payloads and new and existing spent stages to the maximum extent practicable. The removal of these additional components, beyond those that would be removed under the No Action Alternative or Alternative 1, could reduce the likelihood that visitors would discover payloads or spent stages during their visits to these areas, and would further assist NASA and UAF in meeting the requirements of the special use permits for Arctic and Yukon Flats NWRs. However, it is possible that other signs of human activity, including ground scars, ruts, and areas of cleared vegetation, could be present following a more intrusive recovery, which could be discovered by recreational users.

Increased impacts associated with search and recovery operations on recreational opportunities are expected under Alternative 2 compared to Alternative 1 or the No Action Alternative. Impacts on persons participating in recreational activities in areas within the PFRR launch corridor initial search activities would be adverse, localized, negligible in intensity, and short-term in duration because most of these activities would take place in the winter months, when there are few visitors to these areas. Recovery operations would be limited to a small number of days, when helicopters would be recovering payloads or spent stages under Alternative 2. Under Alternative 2, these activities are estimated to last up to 16 days annually and would be spread across downrange lands.

As discussed in Section 4.8.2.2, during recovery operations, persons participating in recreational activities within sight or earshot of the recovery operation may hear or see a helicopter working in the area or a fixed-wing plane flying to pick up a recovered payload. The impacts associated with these activities would be similar to those associated with planes dropping visitors off at various landing spots throughout downrange lands; however, impacts could be greatest in Arctic NWR due to low baseline levels of helicopter use. In the case that recreational users were to discover a piece of flight hardware, it could negatively affect their experience, particularly those persons intending to have a wilderness experience. Others may find it a positive experience to discover a spent stage or payload. It is expected that those persons engaged in hiking and rafting would be the most sensitive to finding flight hardware, with hunters, trappers, and snow machines the most tolerant. The impact would be on a person-by-person basis and would be influenced by the perception of the individual. In summary, anticipated impacts on recreational activities would be adverse, localized, negligible in intensity, and short-term in duration.

4.8.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on land use and recreation under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.8.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could reduce the probability that spent stages or payloads would land within these areas and therefore reduce the need to recover spent stages or payloads from these areas.

4.8.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on land use and recreation under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.8.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories could reduce the probability that spent stages or payloads would land within these areas and therefore reduce the need to recover spent stages or payloads from these areas.

4.8.7 Summer Launches

Summer launches could result in additional safety concerns because areas within the PFRR launch corridor are used more heavily during the summer months for camping, hunting, and recreation (see Section 4.13, Health and Safety). It is possible that visitors would voluntarily suspend or relocate their planned activities upon reading the posted notices; the potential duration of this could vary from days up to several weeks if optimum science conditions are not met until the end of the launch window. It is also possible that downrange "clear" zones would need to be established to ensure public safety, thereby restricting public access to these areas. These impacts would be greater due to the increased public use of downrange lands within the summer months and potential duration of restricted access and user displacement in planned impact areas, and would likely be considered moderate and short-term. However, in the event that such an operation would be proposed, substantial coordination with downrange landowners would be required to reduce potential impacts to the greatest extent practicable.

4.9 CULTURAL RESOURCES

4.9.1 Methodology

Analysis of potential impacts on cultural resources considers both direct and indirect impacts. Direct impacts may occur by physically altering, damaging, or destroying all or part of a resource; altering characteristics of the surrounding environment that contribute to the resource's significance; introducing visual or audible elements that are out of character with the property or that alter its setting; or neglecting the resource to the extent that it deteriorates or is destroyed. For archaeological resources, there is no distinction between permanent and temporary disturbance or short-term and long-term effects; because of the unique nature of archaeological deposits, effects on cultural resources from ground disturbance are permanent and cannot be reversed.

Direct impacts can be assessed by identifying the types and locations of proposed activities and determining the exact location of cultural resources that could be affected. Direct impacts that could occur during the launch phase would be limited to the possible effect of a rocket component landing on a historic property. No alterations to buildings or the launch facility are included in this project. Direct impacts from the alternatives could also occur during recovery efforts. Ground-disturbing activities that could occur during recovery efforts have the potential to adversely impact historic properties either through destruction of the resource or through damaging the resource's integrity, a key criterion for determining a historic resource's eligibility for nomination to the National Register of Historic Places (NRHP) **(16 U.S.C. 470 *et seq.*)**. These activities could include travel to and from the recovery location, removal of rocket components, and human trampling. If a rocket component were to land on or in a historic property, removal of the rocket pieces could further damage the cultural resource.

Indirect impacts may result from project-related actions that eventually lead to effects. Indirect impacts may also result from effects on property value or changes in use of historic architectural resources. It is unlikely that the launch phase or recovery efforts would result in indirect impacts on historic properties.

Site types that could be affected by payload or spent stage impacts include Alaska Native archaeological sites, which may also include aboveground structures (*e.g.,* remains of habitations, stone tent rings, driftwood or whalebone house frames, cemeteries, caribou drive lines or fences and corrals, camps, lithic scatters, housepits), or historic era sites, which may be associated with Alaska Natives or Euroamericans (*e.g.,* U.S. military from World War II and Cold War eras, gold mining, mineral and oil exploration, homesteading, transportation, aviation, cemeteries, and other architecture).

Section 106 of the National Historic Preservation Act (NHPA) **(16 U.S.C. 470 *et seq.*)** requires agencies to seek ways to avoid, minimize, or mitigate adverse impacts on cultural resources. Because the size of the area of potential effect (APE) is extremely large and the information about cultural resources is both scarce and uneven over the area, it is not possible to identify all cultural resources in the APE. Furthermore, due to the nature of the flight path of each rocket, it is not possible to precisely predict the impact point for each rocket stage. However, because the frequency of rocket launches is low and the distribution of sites scattered, it is unlikely that impact points will affect cultural resources. In the rare event of an impact, although it could be adverse to the specific resource, it would be limited to that resource, and the overall impact on the full complement of cultural resources within the launch corridor would be negligible.

Historic properties within the APE were identified through examination of NRHP records and records at the Alaska Office of History and Archaeology, also known as the State Historic Preservation Office (SHPO). Cultural resources that have not been formally evaluated for NRHP eligibility are treated as historic properties (*i.e.,* resources that are eligible for listing in the NRHP) until a formal evaluation is made. NASA is currently consulting with the Alaska SHPO, appropriate Alaska Native tribes, and interested parties regarding the effects of the alternatives on cultural resources.

4.9.2 No Action Alternative

Under the No Action Alternative, NASA and UAF would continue to operate the SRP at PFRR in a manner consistent with current operations. Under the anticipated launch schedule of an average of four launches annually, there is an extremely low probability of hitting any specific location. Launches during the winter would likely reduce the potential impact if a landing was to occur on a cultural resource, as snow and ice and frozen ground would reduce surface and subsurface damage. To date, no impacts on cultural resources have been documented through the existing SRP launch and limited recovery program.

NASA would continue to coordinate with agencies and Alaska Natives according to Section 106 of NHPA, NASA regulations, and other pertinent laws and regulations, as appropriate.

4.9.3 Alternative 1 – Environmentally Responsible Search and Recovery

Under Alternative 1, launches would remain at the same level as anticipated under the No Action Alternative, with the same extremely low probability of landing on any specific location, including a historic property.

The airborne search for rocket stages and payloads would have no impact on archaeological or architectural cultural resources. There is a minor potential for impact on properties of traditional religious and cultural importance from search and recovery flights if the noise from aircraft were to intrude on a ceremony. However, because of the infrequency of launches, and thus of search missions, it is unlikely that the search flights would add significantly to existing air traffic. No properties of traditional religious and cultural importance have been identified by Alaska Natives or other groups within the APE, so impacts are anticipated to be negligible. If any such properties were to be identified through the NHPA Section 106 and government-to-government processes, then sensitivity to scheduling requirements would be likely to mitigate any potential impact.

Recovery efforts would occur during the thaw. Activities could include helicopter landing and takeoff; actual recovery of the rocket stage could entail crewmembers walking around the impact location and digging to excavate a rocket component, potentially followed by hauling and/or trampling of the vicinity. These actions have the potential to impact historic properties if a rocket stage were to land on or in the vicinity of such a resource. There would be an associated potential indirect impact on a resource if recovery led to identification of a site that was later purposefully disturbed (*e.g.,* through the illegal collection of artifacts). However, the low probability of hitting such a resource or of one being near a recovery location means that impacts are anticipated to be negligible. Additionally, where land-disturbing removal activities would most likely be conducted with hand tools, it would further reduce the potential for effects.

4.9.4 Alternative 2 – Maximum Cleanup Search and Recovery

Impacts and the potential for adverse impacts under Alternative 2 are essentially the same as for Alternative 1. Because there would be a greater number of recovery activities under this alternative compared to Alternative 1, there would be a greater possibility of disturbing a historic property. However, the low probability of landing on such a resource or of one being near a recovery location would continue to mean that impacts are anticipated to be negligible.

4.9.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts and the potential for adverse impacts on cultural resources under Alternative 3 are basically the same as for Alternative 1. Impacts are anticipated to be negligible.

4.9.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts and the potential for adverse impacts on cultural resources under Alternative 4 are basically the same as for Alternative 2. Impacts are anticipated to be negligible.

4.9.7 Summer Launches

The launch phase of the mission would have no effect on historic properties. The impact point could experience greater effect if the ground were thawed than during the winter, when the ground is frozen. If the impact point were to be on or very near a cultural resource, and if that resource were a historic property, this could have a greater effect than if the rocket fell during the winter. However, the likelihood of a rocket impacting a historic property is extremely low; thus, it is unlikely that summer launches would adversely impact historic properties.

In the event that a summer launch were proposed in the future, additional consultation with Alaska Natives and landowners would help determine if the seasonality of launches would make a difference in the already remote possibility of having any effect on properties of traditional religious and cultural importance.

4.10 SUBSISTENCE USE RESOURCES

This section describes potential impacts on subsistence use resources in and around PFRR and under the launch corridor.

4.10.1 Methodology

Many small communities in Alaska are wholly or largely dependent on subsistence use of renewable resources. Subsistence use can be the principal means of support for communities and families that do not participate in a wage-oriented economy. Subsistence activities provide a means for economic self-sufficiency, particularly for rural communities, which may not have regular access to year-round employment or year-round access to make household food purchases.

Section 810(a) of ANILCA states, "In determining whether to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands under any provision of law authorizing such actions, the head of the Federal agency having primary jurisdiction over such lands or his designee shall evaluate the effect of such use, occupancy, or disposition on subsistence uses and needs…" (ANILCA Title VIII, §810[a])." In this *Draft PFRR EIS*, BLM and USFWS are the Federal agencies that have primary jurisdiction over the majority of lands within the PFRR flight zones. Therefore, this section and the evaluation provided in Appendix D have been prepared to satisfy the ANILCA evaluation requirements for BLM and USFWS. ANILCA requires that this evaluation include findings on three specific issues: (1) the effect of use, occupancy, or disposition on subsistence uses and needs; (2) the availability of other lands for the purposes sought to be achieved; and (3) other alternatives that would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes **(16 U.S.C. 3120)**.

To determine if a significant restriction of subsistence uses and needs may result from any of the alternatives under consideration in this EIS, including their cumulative effects, the following three factors are considered: (1) the reduction in the availability of subsistence resources caused by a decline in the population or amount of harvestable resources; (2) reductions in the availability of resources used for subsistence purposes caused by alteration of their normal location and distribution patterns; and (3) limitations on access to subsistence resources, including from increased competition for the resources. A significant restriction to subsistence may occur in at least two instances: (1) when an action substantially reduces populations of harvestable resources or their availability to subsistence users and (2) when an action substantially limits access by subsistence users to these resources. This section evaluates whether the alternatives being considered regarding future operations at PFRR would cause a significant restriction to subsistence. If a significant restriction to subsistence is projected, it would constitute a major adverse impact on those communities dependent on subsistence resources. For these remote communities, even short-term restrictions could have an adverse impact on their ability to harvest subsistence resources.

The ANILCA Section 810(a) Summary of Evaluations and Findings is presented in Appendix D.

4.10.2 No Action Alternative

4.10.2.1 *Launch Operations*

Under the No Action Alternative, launches from PFRR and subsequent search and recovery operations would continue as they are currently conducted. An average of four launches per year, up to a maximum of eight launches, would be conducted. Payloads and spent stages would be recovered if required for scientific purposes or requested by the landowner.

NASA and UAF have been launching suborbital rockets from PFRR since the late 1960s. During that time, subsistence activities continued within the launch corridor without known interruption due to these activities. The launches are typically performed during the night or under darkness, when subsistence activities generally do not take place except during the winter months, when darkness lasts longer than daytime. Landowners and administrators (BLM and USFWS) downrange of PFRR are notified prior to any launches consistent with existing procedures and safety requirements. Launches occur within the Fairbanks North Star Borough, which is considered a nonrural area under Federal subsistence regulations and a non-subsistence area under state regulations. Therefore, it is not likely that subsistence activities would be conducted in the immediate vicinity of the PFRR launch site. Subsistence activities are; however, conducted downrange within the PFRR flight zones.

Since launches are conducted in winter, typically during darkness, the subsistence activities would vary depending on the availability of light and the open seasons for various activities. The primary subsistence activities would include gathering vegetation such as wood for fuel or other plants for ceremonial purposes, hunting, trapping, and fishing. Of these activities, hunting is considered to be the most noise sensitive activity. Many of the large land mammals hunted for subsistence, such as bear, caribou, and moose have multiple open seasons throughout the year or the open season extends through the entire year depending on the Game Management Unit. Previous reports have identified subsistence use areas within PFRR in which subsistence activities are carried out on a regular basis. Appendix D provides maps of the subsistence use areas for various subsistence resources identified in the *Proposed Land Exchange Yukon Flats National Wildlife Refuge Final Environmental Impact Statement* **(USFWS 2010a)** and the *Arctic National Wildlife Refuge Draft Revised Comprehensive Conservation Plan* **(USFWS 2011c)** for the villages of Arctic Village, Beaver, Birch Creek, Chalkyitsik, Fort Yukon, Kaktovik, Stevens Village, and Venetie. These areas are defined by a number of factors including habitat and migration patterns of the wildlife and accessibility of the areas to individuals participating in subsistence. Appendix D also provides maps of these subsistence use areas in relation to the predicted impact areas for spent stages and payloads. Of these subsistence use areas, the areas for Arctic Village, Beaver, Fort Yukon, Stevens Village, and Venetie are included or in close proximity to predicted impact points for spent stages or payloads. As a result, subsistence activities conducted by residents in these villages are more likely to experience potential impacts.

Of these potential impacts, disturbance to wildlife and the harvest of wildlife from a launch would be temporary and related primarily to the noise from impact of the spent stages or payloads as they come back to Earth. As described in Section 4.5, “Noise,” and Section 4.7, “Ecological Resources,” wildlife in the immediate vicinity of an impact area would be exposed to the sound from impact of spent stages. Launches would occur during the winter and in darkness, when migratory species would be absent and most resident species would be inactive. Due to the infrequency of launches and the brief duration of associated noise, species present near the impact site are expected to have negligible to minor short-term behavioral responses, if any, to the sound and are not expected to experience harm as a result (see Section 4.7.5).

Additionally, the amount of land that would be disturbed as a result of such impacts is very small compared with the amount of land being used for subsistence activities. Impact areas for spent stages are estimated to be between 6 and 15 square meters (65 and 160 square feet), and the impact area for payloads is typically even smaller when a payload is equipped with a parachute. As described in Section 4.7.5, effects would most likely be limited to a momentary interruption of routine behaviors, such as foraging, but could extend to individuals temporarily leaving the area immediately surrounding the point of impact. For example, an incoming item hitting the Earth within or very near a herd of caribou (a very unlikely event, see Appendix G) could cause the animals to temporarily take flight in a response similar to the response to a predator. Adverse impacts would be short-term and range from negligible to minor. The chances of a direct impact due to a payload or spent stage striking an individual animal are negligible. Therefore, adverse effects on subsistence activities would also be negligible to minor and short-term. Continued launch activities at PFRR would not result in adverse impacts as described in ANILCA Section 810(a).

4.10.2.2 *Search and Recovery*

Under the No Action Alternative, search and recovery operations would only be undertaken for scientific requirements or at the request of landowners. It is estimated that, on average, recovery would be attempted on one payload annually under this alternative. Therefore, the use of helicopters and fixed-wing aircraft would be minimal and infrequent. Any disturbance to wildlife or the harvest of wildlife for subsistence purposes is likely to be negligible. Overflight by low-flying search and recovery aircraft could have temporary and localized effects on wildlife (see Section 4.7.5). Fixed-wing aircraft flying at altitudes greater than 150 meters (500 feet) AGL would cause minimal, if any, response from wildlife. Lower-level flight, especially combined with maneuvering such as circling during searches, may cause temporary and localized responses such as taking flight by waterfowl or running by ungulates (for example, caribou). Permit stipulations with USFWS recommend minimum altitudes for overflight over Arctic NWR and Yukon Flats NWR lands, which constitute the majority of the area within the PFRR launch corridor, to be 610 meters (2,000 feet) AGL or higher, except under specific conditions, and prohibit the operation of aircraft at altitudes and in flight paths resulting in the herding, harassment, hazing, or driving of wildlife. Search and recovery activities would not be conducted over marine mammal habitat on or adjacent to the Beaufort Sea, so marine mammal species would not be exposed to overflight associated with search and recovery activities. Fish would not be affected at the sound levels associated with overflight at altitudes that would be utilized during search and recovery operations. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.10.3.1 *Launch Operations*

Potential impacts on subsistence activities as a result of launch operations would be the same as those described under the No Action Alternative.

4.10.3.2 *Search and Recovery*

Following launches under Alternative 1, NASA and UAF would attempt to recover payloads and spent stages in an environmentally responsible manner to the extent practicable. In coordination with the landowners and administrators, PFRR would determine if the recovery of the spent stages and payloads is feasible and would not result in any significant additional environmental impacts.

The villages of Arctic Village, Beaver, Fort Yukon, Stevens Village, and Venetie have subsistence use areas within or in close proximity to the predicted impact areas for spent stages and payloads as shown in the maps provided in Appendix D. The search and recovery process would involve fixed-wing and helicopter overflights of the predicted impact sites, as described in Appendix F. Noise from low-flying aircraft would have the potential to startle wildlife and could cause the wildlife to leave the area in which search and recovery operations are taking place. However, these startle effects and departures from the area are expected to be temporary, limited to the relatively short periods that these aircraft would be within earshot of wildlife. Once any disturbance from the low-flying aircraft has ceased, it is expected that wildlife would return to their normal habits and locations.

Initial search operations are planned to be conducted in the winter soon after launch, depending on conditions, to locate and record the impact points and, as such, would have very little effect on most wildlife, as discussed in Section 4.7.4. Recovery operations would primarily take place during the summer, when the spent stages and payloads could be recovered more easily. Therefore, the level of disturbance to wildlife by the search and recovery operations would be spread throughout the year and would most likely last for up to 2 days for each operation, with a majority of operations expected to take a day or less. These operations would also be spread over great distances since the areas where payloads or spent stages may land within PFRR cover thousands of square kilometers; thus, the impacts on wildlife in any given area would be infrequent.

Therefore, any adverse impacts on subsistence resources or the harvest of subsistence resources are expected to be localized, minor, and short-term in duration under Alternative 1. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.10.4.1 *Launch Operations*

Launch operations would be the same under Alternative 2 as described for Alternative 1 and the No Action Alternative.

4.10.4.2 *Search and Recovery*

For search and recovery operations, it is expected that greater efforts would be taken to recover stages and payloads from the areas shown in Table 4–24. Thus, additional time would be spent using fixed-wing aircraft and helicopters throughout PFRR to search and recover spent stages and payloads compared to Alternative 1 and the No Action Alternative.

Under Alternative 2, startle effects and potential disturbance to wildlife and subsistence harvesting activities (such as hunting) would be more extensive than under Alternative 1. However, these activities would continue to be relatively minor and infrequent across the affected areas since they would be spread over great distances. Therefore, any adverse impacts on subsistence resources and harvest of subsistence resources are expected to be localized minor, and short-term in duration. As a result, no restriction of subsistence activities or adverse impact on subsistence resources is anticipated.

4.10.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Impacts on subsistence use and subsistence users under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.10.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not have any additional adverse effect on subsistence activities within PFRR.

4.10.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Impacts on subsistence use and subsistence users under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.10.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not have any additional adverse effect on subsistence activities within PFRR.

4.10.7 Summer Launches

With regard to potential subsistence use, summer launches could result in additional safety concerns because areas within the PFRR launch corridor are used more heavily during the summer months for subsistence uses, leading to more people being present in the launch corridor as opposed to being concentrated within the towns and villages. Additionally, a non-winter launch would present an elevated fire risk. Should a wildfire occur, it could adversely affect both subsistence resources (through either loss and/or displacement) and the ability of rural residents to conduct subsistence activities. The types of resources and residents potentially affected would be highly mission-specific. As such, NASA would need to take these factors into consideration in the event of a summer launch (see Section 4.13, Health and Safety).

4.11 TRANSPORTATION

4.11.1 Methodology

The transportation analysis evaluates impacts associated with transport of materials to PFRR from Wallops Flight Facility (WFF) and search and recovery operations associated with recovery of spent stages and payloads. Rocket motors would be transported by truck from WFF to PFRR with the assumption that there would be two truck trips per launch. The payload associated with each launch would be transported from WFF to PFRR by air cargo, assuming one air transport per launch. Search operations for the payload and spent stages would be performed by fixed-wing aircraft, and recovery operations would be conducted by helicopter. The analysis includes transport of recovered items from the Fairbanks area to the PFRR launch site by truck.

Adverse impacts are presented in terms of the annual number of additional fatalities related to truck accidents and the annual number of additional fatal accidents for air transport/search and recovery missions. These impacts are determined by using truck-specific fatality rates per vehicle-mile and the distance traveled and air cargo/fixed-wing aircraft/helicopter-specific fatal accident rates per flight hour and the number of hours of flight.

For trucks, the U.S. large truck crash fatality rate would be 1.2×10^{-8} fatalities per vehicle-kilometer traveled (1.86×10^{-8} fatalities per vehicle-mile traveled) **(FMCSA 2010)**. This fatality rate is also equal to the 5-year average fatality rate of all vehicles on Alaska rural roads **(USDOT 2011a)**. The large truck crash fatality rate in Canada would be 2.2×10^{-8} fatalities per vehicle-kilometer traveled (3.5×10^{-8} fatalities per vehicle-mile traveled) **(Transport Canada 2010:7)**. The one-way distance traveled by truck from WFF to PFRR in the United States (including within Alaska) would be about 2,800 kilometers (1,800 miles), while the one-way distance traveled in Canada would be about 4,200 kilometers (2,600 miles) **(Mapquest 2011a)**. The total fatality rate would be 1.3×10^{-4} fatalities per trip (one-way). The one-way distance traveled by a large truck to return recovered items to the PFRR launch site from the Fairbanks area would be about 54 kilometers (33 miles) **(Mapquest 2011b)**, for a total fatality rate of 6.2×10^{-7} fatalities per trip (one-way). When calculating the total number of fatalities for each alternative, the two-way distance is used to account for the return trip of a truck.

The worldwide fatal accident rate is 3.4×10^{-7} fatal accidents per flight hour for all jet aircraft. However, using factors to account for the region in which the flight takes place (North America) and the type of operation (scheduled cargo), this rate was adjusted to 2.5×10^{-7} fatal accidents per flight hour **(OGP 2010)**. For purposes of analysis, it is assumed that one cargo flight would occur per launch, with an average of four launches per year occurring under all alternatives. A flight from the Washington, D.C., area to Fairbanks International Airport is assumed to take about 9.5 hours, which is equivalent to a flight from New York City to Anchorage **(Anchorage Daily News 2011)**.

Alaska is known to be a state that has a high number of aircraft accidents in comparison to the rest of the United States; therefore, it is important to use Alaska-specific fatal accident rates for aircraft. The fatal accident rate for fixed-wing, single-engine aircraft has been determined to be 1.22×10^{-5} fatal accidents per flight hour **(Conway *et al.* 2006)**. The fatal accident rate for helicopters has been determined to be 1.48×10^{-5} fatal accidents per flight hour **(Conway *et al.* 2006)**.

Potential adverse impacts can be categorized as being negligible, minor, moderate, or major. For purposes of analysis, negligible impacts are assumed to be impacts much less than 1 fatality or fatal accident per year, taken to be less than or equal to 0.002 fatalities or fatal accidents per year. Minor impacts are assumed to be greater than 0.002 and less than 0.01 fatalities or fatal accidents per year. Moderate impacts are assumed to be greater than 0.01 and less than 0.1 fatalities or fatal accidents per year. Major impacts are assumed to be greater than or equal to 0.1 fatalities or fatal accidents per year. The risk can also be expressed in terms of the following: a negligible impact of 0.002 fatalities per year would be the same as less than 1 chance in 500 years that a fatality would occur. A minor impact is defined as a fatality or fatal accident occurring every 100 to 500 years. A moderate impact is defined as a fatality or fatal accident occurring every 10 to 100 years. A major impact is defined as a fatality or fatal accident occurring in a 10-year period.

Transportation risks should also be kept in perspective related to national data. The average number of traffic fatalities in the United States is about 34,000 per year **(USDOT 2011b)**. While major impacts are assumed to be equivalent to one or more traffic fatalities, in view of the overall ground transportation system, the additional risk would be small. For air transports, there were 68 accidents in the United States involving both scheduled (primarily passenger service) carriers flying aircraft with fewer than 10 passenger seats and on-demand passenger or cargo services using either fixed-wing airplanes or helicopters, with 2 of these accidents involving fatalities **(NTSB 2011)**. An additional fatal aircraft accident occurring due to implementation of one of the analyzed alternatives would therefore be considered more significant compared to the national data than a traffic fatality due to a truck crash.

4.11.2 No Action Alternative

4.11.2.1 *Launch Operations*

Using the total fatality rate per trip for large truck transport provided in Section 4.11 and assuming four launches per year with two truck shipments per launch, the number of traffic fatalities due to shipment of equipment from WFF to the PFRR launch site would be 2.0×10^{-3} fatalities per year. The number of traffic fatalities related to ground transport of new payloads from Fairbanks International Airport to the PFRR launch site would be 5.0×10^{-6} fatalities per year. This impact would be minor, with a risk of about 1 chance in 500 years that a traffic fatality would occur.

Air transport of new payloads from WFF would have a risk of a fatal accident of 9.3×10^{-6} fatal accidents per year, assuming a flight time of 9.5 hours. This impact would be negligible, with a risk of about 1 chance in 110,000 years that a fatal accident would occur.

4.11.2.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of one recovered payload from the Fairbanks area to the PFRR launch site would be 1.2×10^{-6} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 830,000 years that a fatality would occur.

For search and recovery operations, the annual number of flight hours associated with each alternative and mode of transport (*i.e.,* fixed-wing aircraft or helicopter) is provided in Appendix F. Under the No Action Alternative, there would be a total of 12 flight hours for a fixed-wing aircraft and 4 flight hours for a helicopter each year. The risk of a fatal accident associated with a fixed-wing aircraft would be 1.5×10^{-4} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 5.9×10^{-5} fatal accidents per year. The additional risk associated with search and recovery operations under this alternative would be 2.1×10^{-4} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 4,800 years that a fatal accident would occur.

4.11.2.3 *Total Impacts*

The total number of traffic fatalities associated with truck transports during launch and search and recovery operations would be 2.0×10^{-3} fatalities per year. This impact would be minor, with a risk of about 1 chance in 500 years that a traffic fatality would occur. The impact on traffic volume of truck transports related to launch and search and recovery operations would be negligible, based on traffic information in Chapter 3, Section 3.11. The annual average daily traffic count on Steese Highway ranges from 1,500 to 1,800 vehicles, which represents a free-flowing condition; the impact of truck transports due to implementation of this alternative would be much less than 1 percent on the traffic count, with no impact on road conditions.

The total additional risk associated with air transport supporting launch activities and search and recovery operations under this alternative would be 2.1×10^{-4} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 4,800 years that a fatal accident would occur.

4.11.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.11.3.1 *Launch Operations*

Impacts related to ground transportation would be minor, to the same as the impacts presented in Section 4.11.2.1 for the No Action Alternative because there would be no changes to the shipment of equipment from WFF to the PFRR launch site. Impacts related to air transport of new payloads from WFF to Fairbanks also would be the same (negligible) as the No Action Alternative.

4.11.3.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of 12 recovered items from the Fairbanks area to the PFRR launch site would be 1.5×10^{-5} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 67,000 years that a fatality would occur.

Under Alternative 1, there would be an estimated total of 67 flight hours for fixed-wing aircraft and 35 hours of flight time for helicopters each year. The risk of a fatal accident associated with fixed-wing aircraft would be 8.2×10^{-4} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 5.2×10^{-4} fatal accidents per year. The additional risk associated with air transport activities that support search and recovery operations under this alternative would be 1.3×10^{-3} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 770 years that a fatal accident would occur.

4.11.3.3 *Total Impacts*

For truck transports, the overall fatality rate would continue to be 2.0×10^{-3} fatalities per year, taking into account 11 additional truck trips from the Fairbanks area to transport recovered spent stages and payloads to the PFRR launch site as compared to the No Action Alternative. This result equates to a risk of 1 chance in 500 years that a fatality would occur. The impact on traffic volume on Steese Highway would also be negligible.

The total additional risk associated with air transport supporting launch activities and search and recovery operations under this alternative would be 1.3×10^{-3} fatal accidents per year. This impact would be negligible, with a risk of about 1 chance in 770 years that a fatal accident would occur.

4.11.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.11.4.1 *Launch Operations*

Impacts related to ground transportation would be minor, the same as the impacts presented in Section 4.11.2 for the No Action Alternative because there would be no changes to the shipment of equipment from WFF to the PFRR launch site. Impacts related to air transport of new payloads from WFF to Fairbanks also would be the same (negligible) as the No Action Alternative.

4.11.4.2 *Search and Recovery*

The number of traffic fatalities related to ground transport of 20 recovered items from the Fairbanks area to the PFRR launch site would be 2.5×10^{-5} fatalities per year. This impact would be negligible, with a risk of about 1 chance in 40,000 years that a fatality would occur.

Under Alternative 2, there would be an estimated total of 112 flight hours for fixed-wing aircraft and 56 hours of flight time for helicopters each year. The risk of a fatal accident associated with fixed-wing aircraft would be 1.4×10^{-3} fatal accidents per year, while the risk of a fatal accident associated with helicopter operations would be 8.3×10^{-4} fatal accidents per year. The additional risk associated with air transport activities that support search and recovery operations under this alternative would be 2.2×10^{-3} fatal accidents per year. This impact would be minor, with a risk of about 1 chance in 450 years that a fatal accident would occur.

4.11.4.3 *Total Impacts*

Impacts related to truck transportation would be minor, similar to the impacts presented in Section 4.11.3 for Alternative 1, with the total number of traffic fatalities slightly increasing from 2.0×10^{-3} fatalities per year to 2.1×10^{-3} fatalities per year. This increase is a result of eight more truck trips from Fairbanks International Airport for transportation of recovered spent stages and payloads. This result equates to a risk of 1 chance in 480 years that a fatality would occur. The impact on traffic volume on Steese Highway would also be negligible.

The total additional risk associated with air transport activities under this alternative would be 2.2×10^{-3} fatal accidents per year. This impact would be minor, with a risk of about 1 chance in 450 years that a fatal accident would occur.

4.11.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Transportation impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.11.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential transportation impacts for this alternative as compared to Alternative 1 since the same amount of transportation would be required.

4.11.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Transportation impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.11.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential transportation impacts for this alternative as compared to Alternative 2 since the same amount of transportation would be required.

4.11.7 Summer Launches

The transportation impacts should remain the same as those projected for launch operations in the winter even if launches were conducted during the summer because the truck transports and aircraft operations associated with search and recovery activities would occur during the summer under either launch scenario.

4.12 WASTE MANAGEMENT

This section discusses potential impacts of hazardous waste and solid waste generated during NASA SRP launch, recovery, waste treatment, and disposal activities. In addition to discussing potential impacts from hazardous materials, supplemental information is provided to aid the reader in understanding the specific use of each.

4.12.1 Methodology

The analysis is of potential impacts is divided into three activity areas:

- **Launch Operations** – PFRR rocket launch and spill cleanup activities
- **Recovery Activities** – Retrieval of newly spent and existing stages and payloads from various areas of PFRR
- **Waste Treatment and Disposal Activities** – Cleaning of spent rocket stages and disposal of waste materials

Determination of hazardous materials and solid waste impacts is based on analysis of the potential for the launch, recovery, and disposal activities associated with each alternative to use hazardous materials and generate waste. Material and waste quantities were estimated using rocket component manufacturer's information and records of previous launches, which included data on vehicle type and payload and stage impact location and weight. Where necessary, data were estimated for payloads and stages for which historical data were unavailable. For analysis purposes, the quantity of material recovered annually per alternative was calculated based on the alternatives' recovery scenarios.

Assumptions

The actual quantity of material recovered is dependent on whether the items can be located and recovered. Therefore, the estimated weight of material recovered is presented in this section as a range reflecting both a 50 percent location success rate (consistent with recent experience for "new" launches) up to a 100 percent location success rate, which would be NASA's ultimate goal. For the recovery of items from past launches, estimated weights are not presented as a range, as it is expected that if reported and confirmed to be a sounding rocket item, it would most likely be removed.

Classification of Impacts

Classifying impacts from the deposition of sounding rocket materials in downrange lands presents a unique case. PFRR is the only rocket range of its type in the United States, and it is especially unique when one considers the context of downrange lands. Other U.S. ranges typically deposit launch related items almost exclusively in oceanic or desert environments, where recovery is either not feasible or much easier due to the terrain. In conducting this analysis, NASA evaluated potentially applicable waste management regulations and multiple environmental impact assessment documents; however, was unable to locate appropriate standards against which impact levels could then be derived. Therefore, in the absence of such standards, NASA applied best professional judgment in assigning impact levels.

It is important to note that while quantities of waste are presented for all downrange areas, the focus of this section is those areas beyond the Poker Flat North and South Special Use Areas. As these areas are legally designated by the State of Alaska for the impact of rocket items for an indefinite term, quantities of materials deposited within them are subtracted in the final calculation before concluding a particular level of impact.

Potential impacts would be considered negligible if there was no change in quantity of material deposited or recovered. For purposes of analysis potential impacts would be considered minor if deposition of material is 1,000 kilograms (2,200 pounds) or less; moderate if deposition of material ranges from 1,000 to 2,000 kilograms (2,200 to 4,400 pounds); and major if deposition of material is greater than 2,000 kilograms (4,400 pounds). Potential impacts would be considered adverse under alternatives for which the deposition of material exceeds the quantity of material recovered; potential impacts would be considered beneficial under alternatives for which the recovery of material exceeds the quantity of newly deposited material. Regarding duration, a waste management impact would be considered long-term if the effects lasted longer than 5 years, as could be the case for payloads and stages that remain unrecovered from the launch corridor; medium-term if the effect lasted from 1–5 years; and short-term if the change were to persist for less than 1 year, as is the case with temporary storage of hazardous materials and waste.

Disposal activities would be considered significant if the quantity of hazardous waste exceeds PFRR's conditionally exempt small quantity generator status, which restricts UAF and PFRR from generating more than 100 kilograms (220 pounds) of hazardous waste and accumulating more than 1,000 kilograms (2,205 pounds) of hazardous waste per month **(USA 2001)**.

4.12.2 No Action Alternative

4.12.2.1 *Launch Operations*

Future launch activity would remain at a level similar to the level that has occurred at PFRR in the past. The continuation of launch operations would require the use of hazardous materials, some of which would unavoidably land within downrange properties. The following presentation of information not only assesses the potential environmental consequences of these materials, but also provides the reader an understanding of what role they serve in a sounding rocket mission.

Motors **–** All rockets launched from PFRR are solid-fueled and comprise either a double base (nitrocellulose-nitroglycerin) or composite (ammonium perchlorate/aluminum) propellant formulation cast within a hardened steel tube. Chapter 2, Section 2.2 of the *SRP SEIS* defines these propellants in full detail **(NASA 2000a)**. On the forward end of each rocket motor is a steel plate; on the aft end is a composite (*e.g.*, graphite) nozzle. By definition, rocket motors are hazardous due to their ignitable or explosive properties. However, once ignited at the launch site, the rocket motors burn until all propellant is exhausted, rendering the motor casing inert when it lands. Any trace amounts of unburned propellant would not be expected to present explosion or a fire risk. It should be noted that initially following land impact, the rocket motors would be extremely hot; however, following a period of cooling, the motors would not present any acute hazards. Fire risks from launches would be negligible due to the time of year when operations typically occur. A more detailed discussion regarding the quantities of motors expected to land within the ROI is provided below under "Nonhazardous Waste."

Pyrotechnics – In addition to the rocket propellant, each rocket motor contains a series of small explosive charges. To provide perspective regarding size, the largest charge currently employed is just less than 0.3 grams (0.01 ounces). These charges serve two primary functions: rocket motor ignition and separation of the stage after it has finished burning.

In addition to the pyrotechnic systems that would be on all rocket motors, the first stage specifically would also contain several spin motors, the purpose of which is to spin the entire rocket immediately following first stage ignition to improve the stability of the rocket during flight. Payloads also contain a number of the above-described pyrotechnic charges for purposes such as removing doors and nosecones to expose the scientific experiment. The size and number of these charges would be mission-specific and would vary; however, even in the case that all charges were of the largest variety, the total charge mass would be less than 28 grams (1 ounce). Once activated, under normal flight conditions, these pyrotechnic systems would pose no hazard to persons on the ground.

Batteries **–** Small electrical systems are required on each rocket motor such that the ignition and separation functions described above may occur. As only the first stage can be ignited from a ground-based circuit, rechargeable batteries are employed (see **Figure 4–14**). On the forward end of each motor, approximately 1.8 kilograms (4 pounds) of nickel-cadmium cells are housed within rigid plastic containers bolted to the head cap of the motor. To assist in providing perspective, this quantity of batteries is comparable to approximately 48 “AA” cells typically used in consumer electronic devices. Of the total battery mass, approximately 15 percent is the cadmium metal, totaling approximately 270 grams (0.6 pounds) per stage. In addition to the nickel-cadmium cells, small quantities of silver oxide cells are used in the motor ignition systems. Weighing less than a gram each, this equates to an approximate mass of 50 grams (0.1 pounds) onboard each motor. These types of batteries are most commonly used in small personal electronic devices, including wristwatches.

Figure 4–14. Typical Rocket Motor Ignition Battery Pack

In addition to the batteries onboard the rocket motor, the payload would contain batteries for the ACS, telemetry, and scientific experiments (see **Figure 4–15**). The total mass of batteries onboard would vary based upon mission requirements; however, a typical mission would be expected to employ approximately 9 kilograms (20 pounds) of nickel-cadmium batteries. This would equate to approximately three packs of 24 “C” cells and single packs of 24 and 16 “A” cells. Assuming that the payload’s batteries contain 15 percent cadmium by mass, the total cadmium returning to land would be approximately 1.4 kilograms (3 pounds) per flight.

Figure 4–15. Typical Payload Battery Configuration

The primary concern regarding the onboard batteries would be the potential for cadmium to enter the environment after the rocket motor returned to Earth. Although it is a trace metal found naturally in the Earth's crust and in oceanic waters, cadmium can be harmful to people and wildlife if elevated concentrations enter the body. Cadmium is efficiently taken up by plants and can therefore enter the food chain for humans and animals. In aquatic systems, it has been shown to accumulate in fish, shellfish, and algae. Although it does not break down in the environment, it may be affected by physical and chemical processes that influence its mobility, bioavailability, and residence time in different settings **(ASTDR 2008)**.

For cadmium to present an environmental or health risk, it must first become exposed such that it comes in contact with an environmental medium such as soil or water. It would be very unlikely that the force of impact would rupture the individual battery cells. Although the batteries are located on the forward end of the rocket motor (which would be the end that would most likely impact the ground first), they are constructed of a steel casing and are packaged in a rigid plastic container that is bolted to an aluminum plate within the rocket motor head cap. In the case of a payload, which would likely land on its side, the batteries are similarly mounted to an aluminum frame that is then encased by an aluminum “skin.” Essentially, for the batteries to be punctured, the motor or payload would need to land directly on a rigid, sharp object (analogous to a thick section of steel rebar) for this to happen. Two impact scenarios for fin-stabilized motors are most likely. If the stage were to penetrate the ground or water surface, the batteries would remain intact; however, likely dislodging from the mounting plate several feet below the surface. In the second scenario, if the motor landed on a surface that it could not penetrate, the first several feet of the motor would “peel” back and land on its side, likely dislodging the battery packs to an area adjacent to the impact site, but again it would be very unlikely that the batteries themselves would rupture. In the case of a finless stage or payload, the outside structure would most likely sustain the most damage, with the potential for dislodging the batteries, but it is unlikely that individual cells would expose their internal cadmium-containing contents **(Wilcox 2012)**.

Over time, exposure to air and water would likely cause the ends of the batteries to corrode first. At that point, once soil and water come in contact with the cadmium metal, it would slowly dissolve, releasing small concentrations of cadmium in the local area. The eventual fate of the cadmium would be highly dependent upon its location. For example, if located in an upland area, the released cadmium would likely bind to the soil particles and be taken up by nearby plants. Cadmium in soil may leach into water; however, this would be most pronounced under acidic conditions (*e.g.,* in the presence of acid rain or industrial activities), which would not be common within the ROI.

In wetland areas, such as Yukon Flats NWR, the mobility and plant availability of cadmium in wetland soils would be substantially different from upland soils. Cadmium tends to be retained more strongly in wetland soils and is more available to plants under upland conditions **(Gambrell 1994)**. **Debusk *et al.* (1996)** studied the retention of cadmium in wetland systems. Differences between measured concentrations in inflow and outflow samples indicated that approximately half of the added cadmium was retained. Experiments showed that nearly all trace metals were present in the sediments in a form that is of limited bioavailability and toxicity.

Cadmium is more mobile in aquatic environments than most other heavy metals (*e.g.,* lead). In some riverine settings within the ROI, cadmium would likely remain it its dissolved (bioavailable) form due to the surface water’s low organic content; however, surface waters that drain areas with higher organic soil content would lend to the formation of insoluble, less bioavailable complexes that would end up in the sediment bed.

In addition to the cadmium found in the batteries themselves, very small quantities of lead containing solder are used on sounding rocket electrical systems. Lead is a heavy metal that is harmful to people and wildlife in elevated concentrations. Although the majority of electrical systems are connected with crimps, some soldered connections are still employed, including those in the battery packs. It is estimated that approximately 100 grams (3.5 ounces) of solder would be used on a rocket’s entire electrical system, with 40 percent (40 grams [1.4 ounces]) of this solder consisting of lead. To assist in providing perspective, this quantity of lead is slightly more than what is contained within a single 12-gauge shotgun shell used for small-game hunting.

Insulation Materials – For some older rocket motor stages, the remaining insulation within the steel tube may contain asbestos materials embedded in resins that could present specific hazards **(Hesh 2011; Wilkie 1981)**. Per the definition in Section 112 of the CAA, an asbestos-containing material is one that contains more than 1 percent asbestos; a recent insulation sample collected and analyzed per EPA protocol indicated that the insulation contained about 15 percent asbestos. A key consideration in assessing asbestos-related hazards to humans is whether the asbestos-containing material would readily release asbestos fibers when damaged or disturbed. The term “friable” is used to define those asbestos-containing substances that, when dry, can be crumbled or reduced to powder by normal hand pressure. Even if an asbestos-containing material is non-friable, it could still present a hazard if it is grinded or cut. In the instance of the motor that was recently sampled, it was found to be non-friable; however, the state of weathering and deterioration would make the friability determination case-specific.

If a person were to handle or cut up the insulation without employing appropriate protective measures, there would be the potential for an uptake of asbestos-containing materials. Airborne dust concentrations of 7.5 fibers per milliliter (48 fibers per cubic inch) were measured while cleaning one type of asbestos insulation (Durestos) used in rocket motors with a wire brush **(Wilkie 1981)**. This concentration level is typical of what asbestos workers were once exposed to on a routine, continuous 40-hour-per-week basis **(ATSDR 2001)**. These short-term concentrations are higher than concentrations now permitted for U.S. workers by the Occupational Safety and Health Administration (OSHA) for an 8-hour day (0.1 fibers per milliliter [0.64 fibers per cubic inch]) or a 30-minute excursion limit of 1.0 fiber per milliliter (6.4 fibers per cubic inch) for construction or shipyard workers **(ATSDR 2001)**. If a person lacking proper personal protective equipment were exposed to 7.5 fibers per milliliter (48 fibers per cubic inch) for 15 minutes, the exposure would be approximately equivalent to that permitted of a worker over about 20 hours at the time-weighted working limit of 0.1 fibers per milliliter (0.64 fibers per cubic inch). The total uptake of respirable materials; however, even if they were cut up without respiratory protection, would be limited compared to long-term uptake by persons working daily with asbestos materials. Asbestos-related lung diseases (malignant and nonmalignant) or signs of these diseases have been reported in groups of occupationally exposed humans with cumulative exposures ranging from about 5 to 1,200 fibers per year per milliliter (0.64 to 7,700 fibers per year per cubic inch) **(ATSDR 2001)**. Therefore, continuous 40-hour-per-week, 50-week-per-year exposure to asbestos at the levels associated with handling rocket motor insulation would be necessary to result in long-term health impacts. Thus, no health impacts are expected from attempting to cut up a rocket motor or from short-term exposure to potential asbestos-containing materials other than the risk of injury from cuts or strains from handling heavy parts. As there would be limited recovery or disassembly of rocket motors under the No Action Alternative, potential risks to PFRR recovery staff would be minimal; however, as there would be a continuing presence of the motors downrange, users of downrange lands could be more likely to encounter the motors and could thus be exposed to asbestos-containing materials. However, as summarized above, expected hazards would be very low.

Pressure Systems – Onboard the payload section of the rocket are small cylinders of high pressure (generally 5,000 pounds per square inch) compressed gas, typically argon or nitrogen (see **Figure 4–16**). These gases are vented during normal flight to align the payload in optimum position for taking its respective measurement. The typical quantity onboard a sounding rocket is small, estimated to be approximately 0.009 cubic meters (0.05 cubic feet). Both gases are nonhazardous; improper handling or damage to the cylinder could cause the cylinder to rupture or act as a projectile. However, the likelihood of such an incident occurring would be very low as this system is designed to vent its contents during reentry.

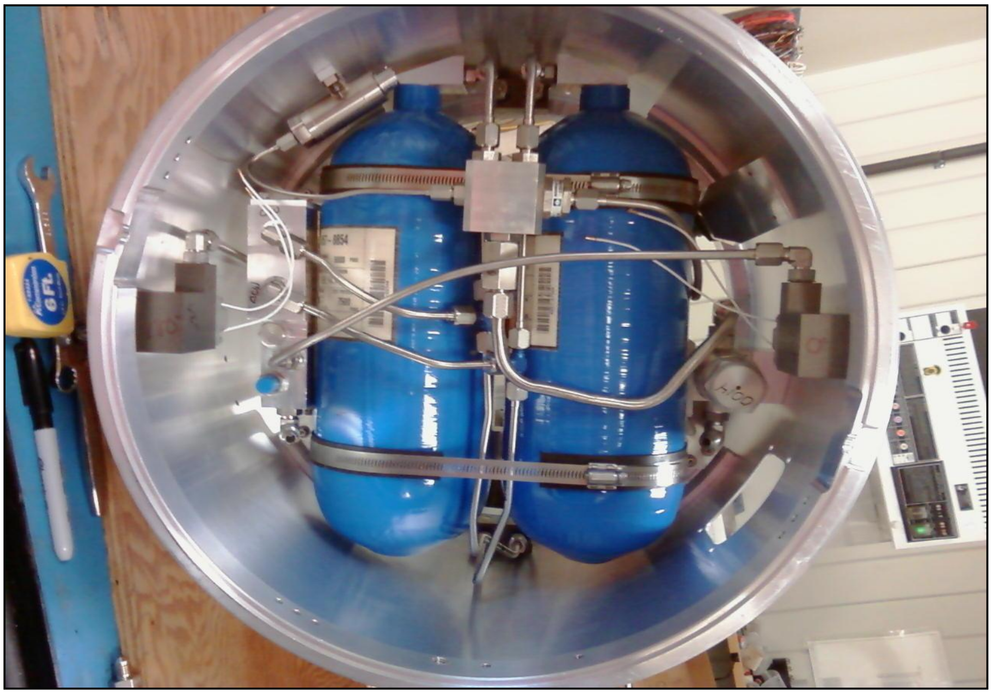


Figure 4–16. Typical 43-Centimeter-Diameter (17-Inch-Diameter) Payload High Pressure Tank Configuration

Chemical Tracers – The use of small quantities of metal vapors or TMA for the study of upper-atmospheric processes is discussed in detail in Chapter 2, Section 2.1.2.2 of this EIS. To help provide perspective regarding size, for some TMA payloads (the most commonly employed tracer), modules are released during flight with each containing approximately 380 milliliters (12.9 ounces) of the liquid—slightly more than the contents of a typical soda can. Larger canisters are most commonly used as they release the material along a longer duration of the trajectory and typically hold approximately 6 liters (1.6 gallons). In general, the primary on-the-ground hazard associated with these materials is the potential for fire or burns. However, during launch preparations, specialized procedures are employed to ensure the safety of personnel. During normal flight, these materials are released high in the atmosphere, with only trace amounts (estimated to be less than 100 grams [3.5 ounces]) present in hardware that returns to Earth. The small soda-can-sized modules would not contain any residual as they rupture during flight; the most likely location of the trace quantities would be within the piping of the canister-type systems.

Calibration Sources – The potential exists that future payloads could use small amounts of radioactive materials as scientific instrument components. For the purposes of this EIS, the amount of radioactive material that could be carried, and thus launched, is strictly limited by the approval authority level delegated to the NASA Nuclear Flight Safety Assurance Manager (NFSAM) by the most current revision of NASA Procedural Requirement 8715.3, *NASA General Safety Program Requirements*. Per NASA policy, the NFSAM may approve launch for small quantities of radioactive material that have been shown to present no substantial public hazard. As part of the approval process, the payload manager must prepare a Radioactive Materials Report (RMR) that describes all of the radioactive materials to be used. The RMR would be submitted to the NFSAM for safety review and approval. A key decision point during this review is the calculation of what is known as the A2 Mission Multiple.[5] If a radioactive material is approved for use, the land management agencies and landowners within the PFRR launch corridor would be notified immediately of NASA's plans.

To provide perspective regarding the size of typical calibration sources flown on sounding rockets, a recent mission at White Sands Missile Range (36.264) that contained two sources had a mission multiple of approximately 5×10^{-5}. Assuming that the average activity in a single smoke detector containing americium-241 is about one microcurie (one millionth of a curie), it would have a mission multiple of 2×10^{-4}, which would be four times greater than that of the referenced mission.

All of such payloads would be equipped with location and recovery systems, and would be immediately removed from downrange lands following launch. Therefore, the use of small quantities radioactive materials in payloads would not present any measurable risk to the public or to the environment.

***Balance Weights* –** To ensure that the spinning rocket components do not "wobble," between 2.3 and 4.5 kilograms (5 and 10 pounds) of lead balance weights are employed on most sounding rocket payloads. These weights would typically be in the form of 0.6- or 1.3-centimeter-thick (0.25- or 0.5-inch-thick) curved plates that are bolted to the inside of the payload skin sections. It would be highly unlikely that these weights would be dislodged such that they would separate from the payload upon impact **(Wilcox 2012)**.

***Launch Site Generated Wastes* –** Materials typically used during launch preparation activities and in rocket stages and payloads include paints, oils, solvents, photographic and cleaning solutions, and bottled gases. Continued operations at PFRR would result in the generation of small quantities of hazardous waste at the PFRR launch site. Hazardous waste would continue to be managed and disposed of by the UAF Risk Management Office. All NASA SRP missions include an inventory of all hazardous materials and disposal methods used for that particular launch.

PFRR does not have a Hazardous Waste Contingency Plan or a Spill Prevention, Control, and Countermeasures Plan because of the small quantity of materials kept on site, so procedures set forth in the UAF Health, Safety and Risk Management Policies are followed in the event of a spill **(UAF 2003a)**. Future launch activity would remain the same as the previous level of activity; therefore, no change in likelihood of a spill is anticipated.

***Nonhazardous Waste* –** As a component of the launch day flight safety assessment, three sizes of helium-filled latex balloons (shown in Chapter 2, Figure 2–24) containing small meteorological sensors (also referred to as "radiosondes," shown below in **Figure 4–17**) or aluminum foil (as a radar target) are released from PFRR. For a typical 6-hour countdown, approximately one each

[5] The A2 mission multiple is a calculated value based on the total amount of radioactive material being launched. It is used in defining the level of review and approval required for launch.

of the mid- and upper-altitude radiosondes and 12 of the lower-flying aluminum foil “chaff” balloons are flown. The balloons would rarely return to the Earth’s surface intact as they would be expected to rise to an altitude between 12 and 30 kilometers (7.5 and 19 miles), where freezing temperatures and expansion (due to lower air pressure) would cause “brittle fracture,” creating spaghetti-like pieces that scatter with prevailing winds. The direction in which the balloons fly would be highly dependent upon atmospheric conditions; however, historic experience shows that these balloons generally take a northerly or easterly track.

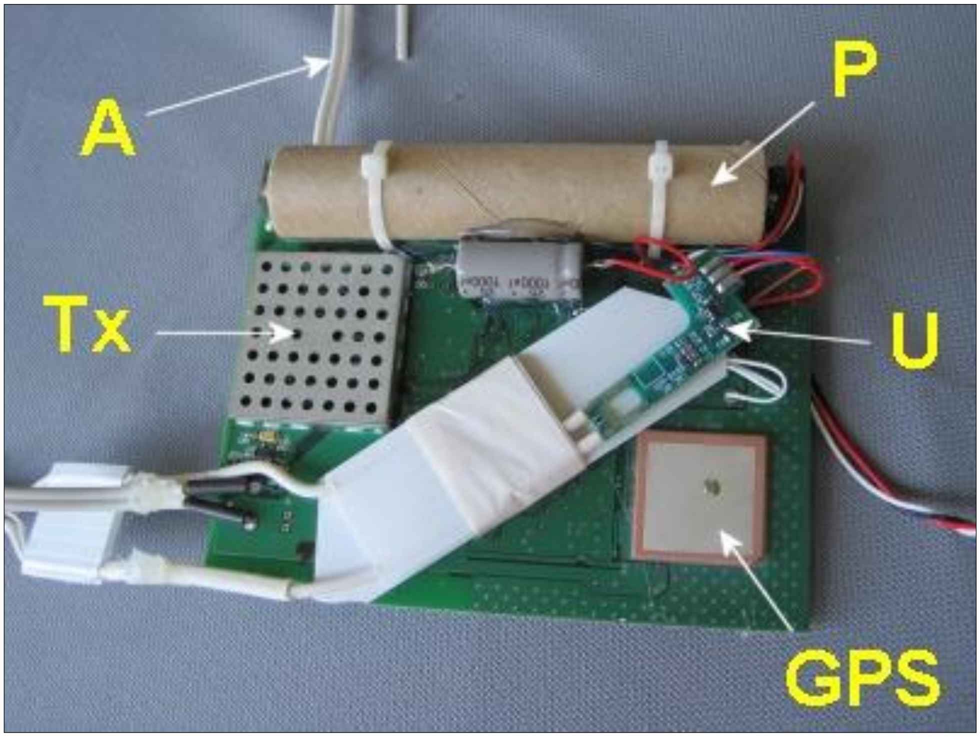


Figure 4–17. GPS Weathersonde Internal Parts; A: Antenna; P: Lithium Battery; Tx: Transmitter; U: Humidity Sensor; GPS: GPS Antenna (photo courtesy Lockheed Martin/Sippican)

Assuming a 320-meter-per-minute (19.2-kilometer-per-hour) ascent rate, the highest altitude balloon would not reach its approximate bursting altitude until about 90 minutes into flight. Over this time, the balloon could travel between approximately 80 and 160 kilometers (50 and 100 miles) from the launch site. Given the lightweight of the multiple pieces to which the balloon would be reduced, they would be spread over a very large area. Once these pieces land, it would be expected that they would break down over time as latex is a biodegradable material. However, given the cold temperatures and limited sunlight experienced within the ROI for approximately half of the year, degradation would likely take longer (in relative terms) than would be expected in warmer climates. In addition, the radiosonde payloads are housed within a 15- by 13- by 8-cenemiter (6- by 5- by 3-inch) polystyrene (“Styrofoam”) box (see **Figure 4–18**) that would return to the ground at the end of flight. Polystyrene does not biodegrade for hundreds of years and is resistant to photolysis (degradation from sunlight); therefore, it would be expected that the boxes would remain within the ROI for years to come. Table 4–28 presents a summary of estimated quantities of “launch support items” that would be flown from PFRR during a typical launch season.

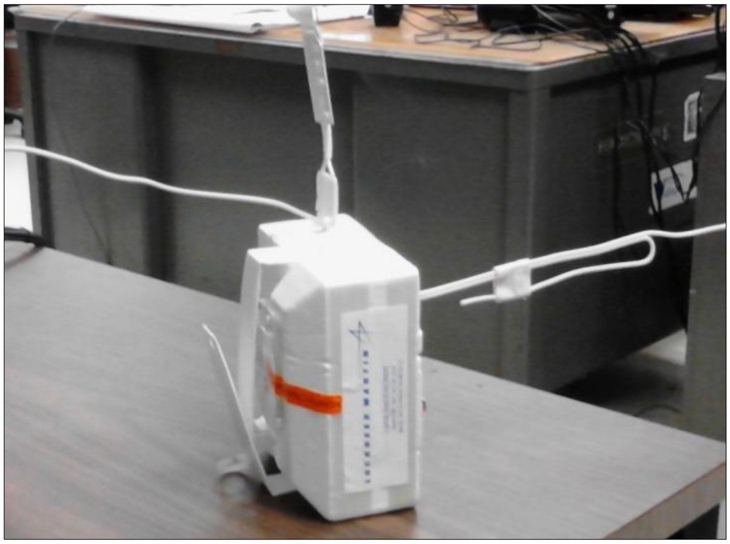


Figure 4–18. GPS Weathersonde Box

4.12.2.2 *Search and Recovery*

The No Action Alternative includes an average of four new launches per year, with a minimum of two launches and a maximum of eight launches. An average of 5,400 kilograms (12,000 pounds) of spent stages and payloads would be deposited in the launch corridor, annually. Of this quantity, 5,000 kilograms (11,000 pounds) would be recoverable. The fourth stage (Nikha) and payload of the BB XII are assumed to land in the Arctic Ocean or Beaufort Sea and would be unrecoverable.

As shown in Table 4–29, recovery of one payload per year from a T-IO class vehicle is anticipated under the No Action Alternative, resulting in the retrieval of a 360-kilogram (800-pound) payload. Payloads from BB XII class vehicles are assumed to land in the Beaufort Sea/Arctic Ocean and would be unrecoverable. As shown in Table 4–31**,** a quantity of approximately 4,600 kilograms (10,000 pounds) of material would be deposited in downrange lands under the No Action Alternative. Of this material, between approximately 2,200 kilograms (4,850 pounds) and 3,40 kilograms (7,500 pounds) would be expected to land within the ADNR Poker Flat North and South special use lands, thus resulting in a net deposition of between 1,200 kilograms (2,650 pounds) and 2,400 kilograms (5,300 pounds) elsewhere, a moderate to major long-term adverse impact.

4.12.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.12.3.1 *Launch Operations*

Under Alternative 1, the launch operations would be the same as described under the No Action Alternative.

4.12.3.2 *Recovery of Newly Launched Payloads and Stages*

Under Alternative 1, assuming an average of four launches per year, one to two payloads and one to two stages would be attempted to be recovered from Yukon Flats NWR, one to two stages from the Venetie/Wind River Area, one to two stages from the White Mountains NRA, for a total of approximately 1,400–2,800 kilograms (3,100–6,200 pounds). Table 4–26 shows the recovery scenario for the recovery of newly launched stages for each of the alternatives evaluated in this EIS.

4.12.3.3 *Recovery of Existing Payloads and Stages*

Approximately 20 different types of rockets have been launched by NASA in the past from PFRR, with impact weights ranging from 5-kilogram (11-pound) payloads to 800-kilogram (1,800-pound) first-stage motors (see **Table 4–25**). Launch operations have resulted in the deposition of approximately 163,000 kilograms (360,000 pounds) of material from the various stages and payloads that have been launched (estimated based on launch information in **(UAF 2011a)**. Fifty payloads have been recovered, resulting in the removal of approximately 12,000 kilograms (26,000 pounds) of debris from the launch corridor. In addition, an estimated 25,000 kilograms (55,000 pounds) of spent stages have been recovered from the launch corridor and returned to the PFRR launch site for disposal. Therefore, approximately 126,000 kilograms (278,000 pounds) of spent stages and payloads are estimated to remain in the launch corridor. As discussed in Chapter 3, Section 3.12, the majority of this material (estimated to be up to 82,000 kilograms [181,000 pounds]) is located in ADNR Poker Flat North and South Special Use Areas that have been set aside by the state for rocket launches.

To calculate the weight of hardware that would be recovered from previously launched items, the vehicles were broken down by the location each would likely impact. The average stage and payload weight per recovery area was calculated based on the impact weight and number of launches of that vehicle type in each recovery area (see **Table 4–26**).

Table 4–25. Historical Launch Vehicles and Impact Weights

Launch Vehicle	First-Stage Impact Weight (kilograms)	Second-Stage Impact Weight (kilograms)	Third-Stage Impact Weight (kilograms)	Fourth-Stage Impact Weight (kilograms)	Payload Impact Weight (kilograms)	Impact Weight per Launch (kilograms)	Number of Vehicles Launched	Total Weight Launched (kilograms)
Black Brant V	270	–	–	–	270	540	9	4,900
Black Brant IX	300	270	–	–	440	1,000	14	14,000
Black Brant X	300	270	94	–	300	960	15	14,500
Black Brant XI	800	610	270	–	360	2,000	2	4,100
Black Brant XII[a]	800	610	270	93	300	2,100	19	39,900
Nike-Apache[b, c]	280	140	–	–	100	520	3	1,500
Nike-Black Brant	280	270	–	–	240	780	7	5,460
Nike-Orion	280	140	–	–	360	770	12	9,300
Nike-Tomahawk	280	68	–	–	65	410	63	26,020
Orion (improved)[d]	140		–	–	68	210	14	2,940
Super Arcas	13		–	–	5	18	10	180
Strypi[e]	540	200	–	–	–	740	1	740
Taurus-Nike-Tomahawk	600	290	68	–	95	1,100	1	1,100
Taurus-Orion	610	140	–	–	140	890	16	14,240
Taurus-Tomahawk	610	68	–	–	38	710	10	7,100
Terrier-Malemute	300	130	–	–	200	630	10	6,300
Terrier-Improved Orion	300	140	–	–	360	810	13	10,500
Total							**219**	**163,000**

a. **Source: Parsch 2005**.
b. **Source: NASA 1972.**
c. Data for the Orion stage were used as a proxy for the Apache stage.
d. **Source: NASA 2005.**
e. **Source: Encyclopedia Astronautica 2011.**

Note: Stage and payload weights and impact distances were obtained from the *Final Supplemental Environmental Impact Statement for Sounding Rocket Program* **(NASA 2000a)** unless otherwise noted. To convert kilograms to pounds, multiply by 2.2046.

Table 4–26. Average Existing Stage and Payload Weight per Recovery Area

Location	Average Stage Weight (kilograms)	Average Payload Weight (kilograms)
ADNR Poker Flat North and South Special Use Areas	400	N/A
White Mountains NRA	290	60
Yukon Flats NWR	140	130
Venetie/Wind River Area	150	85

Note: Numbers rounded to two significant figures. To convert kilograms to pounds, multiply by 2.2046.
Key: ADNR=Alaska Department of Natural Resources; N/A=not applicable; NRA=National Recreation Area; NWR=National Wildlife Refuge.
Source: for impact weight: NASA 2000, 2011a.

Under Alternative 1, it is estimated that one existing stage each would be reported and recovered from the Venetie/Wind River Area, White Mountains NRA, and Yukon Flats NWR, and two existing stages would be recovered from the ADNR Poker Flat North and South Special Use Areas (see Table 4–30). No existing payloads would be expected to be recovered under Alternative 1.

As shown in Table 4–31, approximately 900 to 2,300 kilograms (2,000 to 5,100 pounds) of material would be deposited in downrange lands annually under this alternative. Excluding the materials within the designated ADNR Poker Flat North and South lands, other downrange lands could realize a net reduction of 500 kilograms (1,100 pounds) up to a 900 kilogram (1,980 pounds) increase in materials, which would correspond to either a minor beneficial to minor adverse long-term impact of regional scope.

4.12.3.4 *Waste Treatment and Disposal Practices*

Payloads would not be cleaned before being returned to the principal investigator because they do not contain fuel or motors. The stages would be cleaned once they have been retrieved from the range per the SRP's established procedure, which includes the inspection, removal, and steam cleaning of residue/materials remaining within the rocket motors **(Cornwell 2005)**. Hazardous materials that could be encountered during cleaning include minor quantities of spent fuel residue, asbestos-containing insulation, paint, and batteries. Stages launched in the past likely contain asbestos insulation; workers would take appropriate protective steps to ensure that asbestos residue is contained, stored, and disposed of per the University of Alaska Fairbanks Safety System Policy and Procedure **(UAF 2003a)**. However, it should be noted that wetting an asbestos-containing material is a generally accepted practice for reducing the potential for fibers to be inhaled.

Pressure washing of the spent stages would generate approximately one 208-liter (55-gallon) drum per activity. This waste would be considered hazardous and would be disposed of through the Environmental Health and Safety Risk Management Department at PFRR **(UAF 2011a)**. Under Alternative 1, 2,100 liters (550 gallons) of hazardous rinsate would be generated (see **Table 4-27**). The cleaned stages and other nonhazardous waste would be disposed of or recycled at the Fairbanks North Star Borough's landfill. PFRR is not expected to exceed its Conditionally Exempt Small Quantity Generator status, resulting in a negligible adverse impact.

Table 4–27. Rinsate Volume Generated During Stage Cleaning Activities

	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	Volume of Hazardous Rinsate (liters)	Number Recovered	Volume of Hazardous Rinsate (liters)	Number Recovered	Volume of Hazardous Rinsate (liters)
Newly Spent Stages	0	0	5	1,000	8	1,700
Existing Stages	0	0	5	1,000	8	1,700
Total Volume of Hazardous Rinsate	**0**	**0**	**10**	**2,100**	**16**	**3,300**

Note: To convert liters to gallons, multiply by 0.264.

4.12.4 Alternative 2 – Maximum Cleanup Search and Recovery

Under Alternative 2, the attempted recovery of one to two newly launched payloads would be the same as under Alternative 1. In addition, two newly launched stages would be attempted to be recovered from the Venetie/Wind River Area, along with one to two stages from Yukon Flats NWR, one to two stages from White Mountains NRA, and one to two stages from ADNR Poker Flat North and South Special Use Areas (see Table 4–29). Two payloads from previously launched vehicles would also be recovered annually from the Venetie/Wind River area (see Table 4–30). In addition, two existing stages each would be recovered annually from the Venetie/Wind River Area, White Mountains NRA, Yukon Flats NWR, and the ADNR Poker Flat North and South Special Use Areas.

As shown in Table 4–31, up to a 900-kilogram (2,000-pound) overall reduction could occur, however up to 400 kilograms (880 pounds) of material could be deposited in downrange lands annually under this alternative. Excluding the items within the designated ADNR Poker Flat North and South Special Use Areas, other downrange lands could realize a net reduction of 1,200 kilograms (2,650 pounds) up to a 100-kilogram (220-pound) increase in materials, which would correspond to either a moderate beneficial to minor adverse long-term impact of regional scope.

4.12.4.1 *Waste Treatment and Disposal Practices*

Under Alternative 2 and assuming an average of four launches per year, 3,300 liters (880 gallons) of hazardous rinsate would be generated (see Table 4–27). PFRR is not expected to exceed its Conditionally Exempt Small Quantity Generator status under Alternative 2 even if up to eight launches occurred annually, resulting in a negligible adverse impact.

4.12.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Hazardous materials and hazardous waste impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.12.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential hazardous materials and hazardous waste impacts associated with this alternative compared to those described for Alternative 1. It could however, reduce the potential for such materials to land within the avoided areas.

4.12.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Hazardous materials and hazardous waste impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.12.4, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential hazardous materials and hazardous waste impacts associated with this alternative compared to those described for Alternative 2. It could; however, reduce the potential for such materials to land within the avoided areas.

4.12.7 Summary of the Alternatives

This section includes several tables to provide the reader a comparison of the estimated disposition of flight hardware (rocket motors and payloads) on a per-year basis. **Table 4–28** provides an estimate of launch support hardware flown from PFRR during a typical launch season; **Table 4–29** presents a comparison of newly flown stages; **Table 4–30** presents a comparison of previously flown stages and payloads; and **Table 4–31** shows the total weight recovered (both new and old), assuming four launches per year.

Table 4–28. Estimate of Launch Support Items Flown from PFRR During a Typical Launch Season

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
"Chaff" Latex Balloon	0.1	120	48	96	50–80	ADNR Land or BLM
Mid-Altitude Latex Balloon	0.3	10	12	24	80–100	ADNR Land, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon	1.2	10	48	96	80–160	ADNR Land, BLM, or USFWS Yukon Flats NWR

Table 4–28. Estimate of Launch Support Items Flown from PFRR During a Typical Launch Season (*continued*)

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
Polystyrene Radiosonde Package	0.25	20	20	40	80–160	ADNR Land, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	408	816	4–5	ADNR Land

a. Each launch requires 10 days of countdown with a 6-hour launch window.

b. Estimates in this table do not include instances when several launches would occur on the same day, which would reduce the presented weights as launch support items would be "shared" among all those launches.

Note: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.

Key: ADNR=Alaska Department of Natural Resources; BLM=Bureau of Land Management; kg=kilogram; km=kilometer; USFWS=U. S. Fish and Wildlife Service.

Table 4–29. Possible Recovery Scenarios for Newly Launched Payloads and Stages (four launches per year)

Vehicle	Payload/ Stage	Impact Location	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
			Number Recovered	Weight Recovered (kg)	Number Recovered	Weight Recovered (kg)	Number Recovered	Weight Recovered (kg)
Black Brant XII	Payload	Beaufort Sea	0	0	0	0	0	0
	Talos	ADNR Land	0	0	0	0	1	800
	Taurus	White Mountains NRA	0	0	1–2	600–1,200	1–2	600–1,200
	Black Brant V	Venetie/ Wind River Area	0	0	1–2	270–540	1–2	270–540
	Nihka	Beaufort Sea	0	0	0	0	0	0
Terrier-Improved Orion	Payload	Yukon Flats NWR	1	360	1–2	360–720	1–2	360–720
	Terrier	ADNR Land	0	0	0	0	1	300
	Orion	Yukon Flats NWR	0	0	1–2	140–280	1–2	140–280
TOTAL			**1**	**360**	**4–8**	**1,400–2,800**	**6–10**	**2,500–3,800**
Excluding ADNR Special Use Lands			**1**	**360**	**4–8**	**1,400–2,800**	**4–8**	**1,400–2,700**

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: ADNR=Alaska Department of Natural Resources; kg=kilograms; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Source: for impact weight: NASA 2000a, 2011a.

Table 4–30. Possible Existing Payload and Stage Weight Recovered per Alternative

Recovery Area	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	Weight Recovered (km)	Number Recovered	Weight Recovered (km)	Number Recovered	Weight Recovered (km)
Payloads						
Yukon Flats NWR/Venetie	0	0	0	0	2	170
Stages						
Venetie/Wind River Area	0	0	1	150	2	290
White Mountains NRA	0	0	1	280	2	590
Yukon Flats NWR	0	0	1	140	2	280
ADNR Poker Flat North and South Special Use Areas	0	0	2	780	2	780
TOTAL	**0**	**0**	**5**	**1,300**	**10**	**2,100**
Excluding ADNR Special Use Lands	**0**	**0**	**3**	**500**	**8**	**1,300**

Note: To convert kilograms to pounds, multiply by 2.2046.

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge.

Source: for impact weight: NASA 2000a, 2011a.

Table 4–31. Possible Annual Recovery of Stages and Payloads per Alternative (four launches per year)

	No Action Alternative		Alternatives 1 and 3		Alternatives 2 and 4	
	Number Recovered	**Weight Recovered (kilograms)**	**Number Recovered**	**Weight Recovered (kilograms)**	**Number Recovered**	**Weight Recovered (kilograms)**
Newly Launched Payloads	1	360	1–2	360–720	1–2	360–720
Newly Spent Stages	0	0	3–6	1,000–2,000	4–8	2,100–3,100
Existing Payloads	0	0	0	0	2	170
Existing Stages	0	0	5	1,300	8	1,900
Total	**1**	**360**	**9–13**	**2,700–4,100**	**15–20**	**4,600–5,900**
Excluding ADNR Special Use Lands	**1**	**360**	**7-11**	**1,900–3,300**	**12–16**	**2,700–4,000**
Annual Recoverable Weight Launched	**5,000**		**5,000**		**5,000**	
Recoverable Weight Excluding ADNR Special Use Lands	**2,800**		**2,800**		**2,800**	
Net Weight Deposited Annually in Launch Corridor	**4,600**		**900–2,300**		**(900) –400**	
Net Weight Excluding ADNR Special Use Lands	**2,400**		**(500) –900**		**(1,200) –100**	

Note: To convert kilograms to pounds, multiply by 2.2046.
Source: for impact weight NASA 2000a, 2011a.

4.12.8 Summer Launches

No change in hazardous material and waste use or generation or its impact on the environment is anticipated in the event of a summer launch.

4.13 HEALTH AND SAFETY

4.13.1 Methodology

Human health impacts were addressed by evaluating the potential impacts on workers and the public of each alternative's launch operations and recovery activities.

4.13.1.1 Launch Operations – Worker Health and Safety

The health and safety of workers before, during, and after launches at PFRR was addressed by reviewing past activities and practices, including health and safety records, at PFRR, as well as at other NASA SRP launch locations. Past launch-related activities were found to be well controlled, especially recently, by NASA safety requirements, practices, procedures, and standards **(NPR 8715.3C)**. These practices would be continued or improved for future launch operations due to the implementation of a new *University of Alaska Health and Safety Plan* for PFRR **(UAF 2011b)**.

4.13.1.2 *Launch Operations – Public Health and Safety*

The health and safety of the public before, during, and after launches at PFRR was addressed by first reviewing past activities and practices at PFRR, as well as at other NASA SRP launch locations. All public risks due to launch-related activities were found to be well controlled by NASA Range Safety requirements, practices, procedures, and standards **(NASA 2008; NPR 8715.5A)**. These practices would be continued for future launch operations.

NASA Range Safety requires that the risks to the public be evaluated during the planning stages and updated prior to a launch and demonstrated to meet NASA Range Safety criteria. UAF and PFRR imposed additional range safety criteria. Below are the risk criteria that are applied to sounding rocket launches at PFRR:

- PFRR/UAF: The mission casualty expectancy criterion is 11.4×10^{-6} (1 in 87,700). (This includes the assessment of Alaskan and Canadian areas).
- NASA: Probability of casualty for individuals, applied separately for each hazard, shall be less than 1×10^{-6} (1 in 1,000,000).
- PFRR: Town impact probability criterion is 5×10^{-4} (1 in 2,000).
- PFRR: The probability of impacting outside the range criterion is 1×10^{-2} (1 in 100).
- PFRR: The pipeline impact probability criterion is 1×10^{-5} (1 in 10,000).
- PFRR: Predicted impact must be outside the 1-sigma uncertainty area from a populated U.S. town and outside the 3-sigma uncertainty area from a populated Canadian town or area (see Appendix G).
- PFRR: The Aircraft Hazard Areas must be contained within areas for which clearance has been obtained from the Federal Aviation Administration.

To estimate the risks to the public from future launches for the proposed alternatives, future launches were assumed to be a 50-50 split of the four-stage BB XII, one of the largest launch vehicles available, and the two-stage T-IO. Both of these launch vehicles are relatively new and are expected to be representative of future launches and to collectively represent the risk of future launches. The payloads are also typical in terms of mass so the flight trajectories and impact points of the stages and payloads are also expected to be representative of future launches. Therefore, the Flight Safety Plans for recent BB XII missions, the Lynch Mission **(Skees 2009)** and the Conde Mission **(Skees 2010)**, are expected to be typical of future missions and to well characterize the risks of future missions. The information from these flight safety risk assessments from these recent BB XII and T-IO missions was used to project annual future risks with two, four, and eight launches per year, with a 50-50 split of the two launch vehicles.

Other potential health and safety impacts on the public, such as the potential for fires ignited by spent stages and the hazards associated with encounters with stages in the field, were also addressed.

4.13.1.3 *Search and Recovery – Worker Health and Safety*

The potential health and safety impacts on workers performing the search and recovery operations were based on past experience with recovery operations, which consisted primarily of payloads designed to be recovered and preliminary plans for future spent stage and payload recovery operations. Projected annual worker impacts were estimated for each stage of the search and recovery process, including flight time during the initial search for the payload and flight and helicopter times during the recovery process. Projected impacts were estimated based on the assumed times and workers required for each recovery task, together with established injury and fatality rates for similar types of activities. Specific risks of injury or death associated with time on the ground associated with digging up, disassembling, rigging, and other recovery activities were also estimated. Associated time at PFRR disassembling each payload or spent stage was also included.

4.13.1.4 *Search and Recovery – Public Health and Safety*

Based on past experience with search and recovery operations, which consisted primarily of recovering payloads that were designed to be recovered, and preliminary plans for future spent stage and payload recovery operations, the health and safety risks to the public were found to be negligible. Search and recovery activities would all be conducted with personnel associated with or hired by PFRR for the specific recovery operation. The potential health and safety of any contact or encounters with spent stages or payloads by members of the public is addressed in Section 4.13.2.2. **Table 4–32** describes the intensity of impacts used in the health and safety analysis.

Table 4–32. Description of Intensity and Duration of Potential Health and Safety Impacts

Intensity of Impact	
No effect	Public risks < 0.1 NASA range safety criteria
Negligible	Public risks at or below NASA range safety criteria
Minor	Public property damage to structures, small fires ignited by failed stage, risks to public increased Public safety risks 10 × NASA range safety criteria
Moderate	Injuries and property damage expected Public risks 100 × NASA range safety criteria Workers likely to receive days-off injuries
Major	Worker or public fatalities likely
Duration of Impact	
Short-term	Health impacts or risks occur only during the launch
Medium-term	Health impacts continue for weeks
Long-term	Health impacts continue for years

4.13.2 No Action Alternative

4.13.2.1 *Rocket Launch Worker Health and Safety*

PFRR operates under the health and safety policies and procedures of the University of Alaska **(UAF 2011a, 2011b)**. OSHA's industrial and occupational safety rules and regulations and the State of Alaska's occupational safety and health standards apply as well **(UAF 2011b)**. PFRR complies with these regulations in the areas of industrial and occupational safety and health.

PFRR's operation of the sounding rocket launch range is unique within the university system. Many aspects of its operations are not specifically addressed within university, OSHA, or State of Alaska safety rules. Therefore, a PFRR internal safety policy and *Health and Safety Plan* **(UAF 2011b)** augments those sources to address specific challenges associated with working with equipment and procedures specific to rocket launches.

The worker safety risks inherent in rocket operations in extremely cold weather are expected to continue and not change substantially with any of the anticipated operations. For launch-related operations, the worker safety and accident rates are driven primarily by the number of hours worked, which should be primarily proportional to the number of launches. Thus, the launch-related accident risk would approximately double, with eight launches per year instead of four, and halve, with two launches per year instead of four.

The principal unusual worker hazard at PFRR is working with solid propellant rocket motors and associated hardware. These motors present an explosion and fire hazard in addition to more routine hazards associated with handling large, heavy objects and supporting equipment. NASA requires each SRP mission to prepare a Ground Safety Plan to minimize risk to human life, property, and natural resources. The Ground Safety Plan identifies the hazardous systems that exist on the vehicle and payload and the NASA safety category for each hazardous system. Depending on the safety category during various launch operations, restrictions may be imposed on NASA personnel, NASA contractors, and experimenters.

Typical restrictions include establishment of prelaunch and launch danger areas. For a recent BB XII launch, the prelaunch danger area for the assembled vehicle and payload was within a 152.5-meter (500-foot) radius centered on the vehicle, and the launch danger area was within a 432-meter (1,420-foot) radius centered on the launcher **(Ellis 2009)**. Within the PFRR launch site (which is only accessible by authorized personnel), roadblocks are established to enforce these mandatory safety zones.

In spite of the excellent safety record for workers at PFRR and for NASA's SRP in general, the inherent hazards associated with working with high-energy rockets remain, and the possibility of a serious accident involving a rocket motor exists. Continued adherence to the NASA safety rules should ensure that the risk to the PFRR workers and visitors would remain very low with future missions.

4.13.2.2 *Rocket Launch Public Risks*

As discussed in Chapter 3, Section 3.13.2, the public is protected from the impacts of sounding rockets and their components through the safety policies and practices of the NASA SRP. All

NASA SRP missions are required to prepare both Ground and Flight Safety Plans to minimize risk to human life, property, and natural resources. A Flight Safety Risk Assessment is also prepared for each mission. Both impact and overflight criteria are considered in the Flight Safety Plans and, while risk cannot be entirely eliminated, it is reduced to an acceptable margin.

During the planning process for each mission, the various safety analyses are performed to ensure that the mission can be conducted in accordance with the NASA and PFRR safety requirements identified in Chapter 2, Section 2.1.6. The flight safety risks are calculated by comparing the population within potential impact areas for the stages and payloads for both normal launches and launches where something fails, such as failure of a motor to ignite, and results in the motor impacting an area outside of the planned impact area. Calculations that are performed include evaluation of the probability that anyone within the general population would be harmed (*i.e.*, a "casualty"), the probability that a rocket impact might occur within a town, and the probability that a rocket might impact the Trans-Alaska Pipeline. In addition, the probability that any individual might be directly impacted is also evaluated. Aircraft hazard areas and clear zones are developed and coordinated with the FAA.

The criteria that are imposed are a combination of NASA criteria from NASA's *Range Safety Manual* **(NASA 2008)**, which is common across the U.S. Government rocket launch ranges, and additional criteria or guidelines adopted by UAF and PFRR. In most cases, these criteria are acceptance criteria, and nominally less restrictive risk estimates may be approved on a case-by-case basis with recognition of the conservatism built into the risk calculations.

For each Flight Safety Plan, the potential impact locations for each stage under normal and off-normal conditions are calculated. There is a high level of uncertainty associated with these estimates because of the large number of variables associated with each launch, including wind, temperature, and variations in the performance of the solid rocket fuel. These variations become even more pronounced the higher the payload or spent stage is launched from the launch site. The biggest variants are thrust misalignment, which is a measure of how straight the rocket really is, and uncompensated winds. This is the change in wind from the time it was last measured prior to launch until the instant the rocket is launched (*e.g.*, a wind gust).

There are often some tradeoffs in flight trajectory in terms of azimuth and elevation of the initial trajectory to balance the competing range safety criteria. Often, the goals of minimizing the potential risks to people have to be balanced against other criteria, such as keeping the flight path with impact dispersion areas within the range corridors.

As a result, the predicted impact points have bands of uncertainty associated with them that can vary north and south (downrange) and east and west (cross-range) by relatively small amounts on a percentage basis (for example, 5 to 10 percent), but that end up being relatively large distances for spent stages or payloads that are predicted to land further from the launch site. For example, a typical BB XII launch has a third stage that would be predicted to land approximately 350 kilometers (220 miles) from the launch site with a 1-sigma[6] downrange dispersion of approximately 38 kilometers (24 miles) and a 1-sigma cross-range dispersion of

[6] Sigma or standard deviation is a measure of how much variation or "dispersion" there is from the average (the mean, or, in this case, predicted impact point).

27 square kilometers (10 square miles).[7] Using these dispersion estimates, it is possible to estimate a predicted impact area within the ellipse formed by these dispersion factors. The 1-sigma impact area for this example would be an ellipse with an area of approximately 3,200 square kilometers (1,235 square miles) **(Bowker 2011)**. Using a bivariate circular probability distribution, approximately 39 percent of its launches are expected to land within 1 sigma of the predicted impact point, 86 percent within 2 sigma, and 99 percent within 3 sigma (see Appendix G).

Typical Flight Risks

To estimate the risks to the public from future launches for the proposed alternatives, future launches were assumed to be a 50-50 split of the four-stage BB XII, one of the largest launch vehicles available, and the two-stage T-IO. Both of these launch vehicles are relatively new and are expected to be representative of future launches and to collectively represent the risk of future launches. The payloads are also typical in terms of mass so the flight trajectories and impact points of the stages and payloads are also expected to be representative of future launches. Therefore, the Flight Safety Plans for recent BB XII missions, the Lynch Mission **(Skees 2009)** and the Conde Mission **(Skees 2010)**, are expected to be typical of future missions and to well characterize the risks of future missions.

To confirm that these results would be representative of future launches, the risk analysis for the recent two-stage BB IX Mission, the Bailey Mission **(Skees 2011)**, was also reviewed. This vehicle and mission were selected because a number of these have been flown over the last decade and, while the risks are similar to or smaller than the T-IO, the mission selected did have a higher probability of impacting a town.

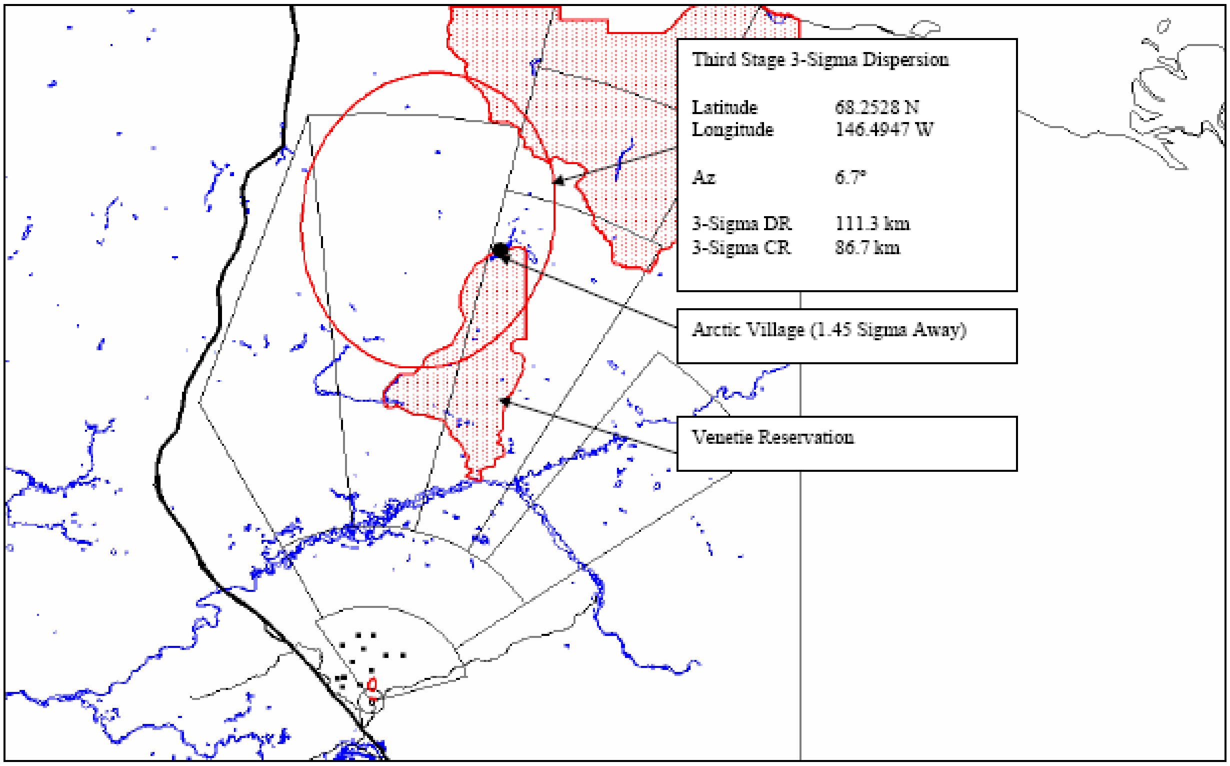
With either launch vehicle, called the "Nominal Case," the "Casualty Expectation," or probability of a casualty among the general public, would be 3.5×10^{-7}, or less or 1 in 3 million. This means that the likelihood of a casualty among the population within the range is negligible. This estimate is far below the NASA acceptance criteria of 30 in a million and the PFRR acceptance criteria of 11.4 in a million.

Even though the probability of a casualty is extremely low, with some missions, villages such as Arctic Village or Beaver have fallen within the impact uncertainty areas and had a nominal probability of 1 in 2,200 (BB XII) and 1 in 630 (T-IO) of a stage landing within the area of the village **(Skees 2009, 2010)**. To ensure that village population data and boundaries of seasonal use areas are considered in mission planning, on an annual basis, PFRR contacts local residents to verify existing information or suggest appropriate changes.

With the BB XII mission, the first stage Talos motor would land about 2 kilometers (1.25 miles) +/- 0.2 kilometers (0.12 miles) downrange within the state land designated for use by PFRR. The second stage Taurus motor would land about 13 kilometers (8 miles) +/- 2 kilometers (1.25 miles) downrange. The third stage Black Brant motor would land about 350 kilometers (220 miles) downrange with 1-sigma uncertainties of 37 kilometers (23 miles) downrange and

[7] Since the launches from PFRR are generally from south to north, downrange dispersion refers to differences in the actual impact point along the south-to-north axis and cross-range dispersion refers to possible differences in the actual impact point along the west-to-east axis (see Appendix G).

29 kilometers (18 miles) cross range, in the Brooks Range area. The fourth stage Nihka motor would land in the Beaufort Sea **(Skees 2009)**. **Figure 4–19** illustrates the BB XII dispersion ellipse for the third-stage motor. For that mission, Arctic Village was approximately 1.45 sigma away from the nominal center of the ellipse. The probability of landing within Arctic Village for that mission was about 1 in 3,000 **(Skees 2009)**.



Source: Skees 2009.

Figure 4–19. Typical Black Brant XII Third-Stage Three-Sigma Dispersion Ellipse

With a T-IO mission, the first-stage Terrier motor would land about 5 kilometers (3 miles) +/- 0.5 kilometers (0.31 miles) within the state land designated for use by PFRR, and the second-stage Orion motor would land about 120 kilometers (75 miles) +/- 15 kilometers (9 miles) (1 sigma) downrange, in the Yukon Flats NWR near Beaver **(Skees 2010)**.

With a BB IX mission, the first-stage Terrier motor would land about 2 kilometers (1.25 miles) +/- 0.2 kilometers (0.12 miles) within the state land designated for use by PFRR, and the second-stage BB Mk1 motor would land about 260 kilometers (160 miles) +/- 24 kilometers (15 miles) (1 sigma) further downrange, with a 30 percent chance of landing in the Venetie lands and a 1 in 4,400 nominal probability of town impact **(Skees 2011)**.

For any launch, the probability of impacting the pipeline would be very small for long-range rockets like the BB XII and is not possible for smaller rockets like the T-IO.

Noise

OSHA limits for employees are 115 dBA for 15 minutes, 97 dBA for 3 hours, and no limit for 75 dBA. The launch noise persists for less than a minute. For the loudest of launch vehicles, the public at the nearest noise-sensitive receptor—Chatanika Lodge, 1.6 kilometers (1 mile) from PFRR—would be exposed, for a few seconds, to a noise level lower than the acceptable 15-minute OSHA exposure level. The public at 11 kilometers (7 miles) would be exposed to a noise level lower than a diesel truck at 15 meters (50 feet), which generates a noise level of about 85 dBA.

Off-Normal Flights and Accidents

On any rocket flight, there is a potential for a failure that results in one or more stages landing outside of the predicted nominal impact areas. While operations at PFRR have been quite safe, there have been launches with malfunctions in which the rockets did not perform as expected. Of 219 NASA SRP launches at PFRR since 1971, 14, or 6.4 percent, of the total launched had some sort of vehicle failure that resulted in failure of the mission and the experiment **(UAF 2011a)**. However, in recent years, the success rate at PFRR has been better, with only 2 vehicle failures since 1997, a success rate of over 96 percent **(UAF 2011a)**.

For both launch vehicles, the failures of most concern are failure of a motor to ignite, which would result in an intact motor impacting the ground at a high velocity, and in-flight failures of an upper-stage motor. If a motor fails to ignite, it is expected to explode on impact with a TNT-equivalent energy of about 100 percent of the propellant mass. In the case of a Black Brant motor, the motor would impact at 344 meters (1,128 feet) per second, with 1,000 kilograms (2,200 pounds) of propellant. The hazard radius would be 72 meters (240 feet), resulting in a lethal area of 16,000 square meters (180,000 square feet) **(Skees 2009)**.

The impact of smaller, un-ignited motors would have smaller lethal areas, but these motors are still expected to explode on impact and potentially spread burning propellant into the immediate vicinity of the impact point. There would also be the potential for an incompletely burned motor to impact the ground, continue burning, and start secondary fires. For typical winter season launches, the cold temperatures and snow cover would limit the potential for secondary fires.

It is notable that for the BB XII and T-IO missions discussed in this EIS, the public accident risks were predominantly driven by the consideration of a motor failing to ignite, which could result in an unfired motor impacting near the BLM Crowberry cabin north of the launch site. If the cabin were unoccupied, the public risk would drop substantially. However, to maximize public safety, it is standing NASA policy to assume that there are two persons in the cabin at all times. PFRR also coordinates directly with BLM to ensure that it is aware of the most current status of the cabin during launch windows.

4.13.2.3 *Annual Impacts*

Table 4–33 also presents the projected annual future risks with two, four, and eight launches per year, assuming a 50-50 split of launches with the BB XII and T-IO launch vehicles. With a nominal launch rate of four per year (two BB IX and two T-IO), the mission casualty expectation is 1.1×10^{-5}. The overall probability of a motor landing within the town limits is about 1 in 260. The overall probability of a motor landing near the pipeline is 1 in 240,000. The probability of a motor landing outside PFRR is 1 in 28. With a launch rate of two per year, the casualty expectation and probabilities are reduced by half. With eight launches per year, the numbers would double.

Table 4–33. Projected Probabilities and Public Risks from Future Sounding Rockets Program Launches from Poker Flat Research Range

	PFRR Mission Risk Criteria[a]	Black Brant XII 40.023 Mission[b]	Terrier-Improved Orion Mission 41.084[c]	Terrier-Black Brant 36.256 Mission[d]	Projected Cumulative Annual Risk and Probabilities		
					With 2 launches per year	With 4 launches per year	With 8 launches per year
Total Risk: Nominal + Accident							
Risk of a casualty among members of the public[e]	1.1×10^{-5}	2.1×10^{-6}	3.5×10^{-6}	1.4×10^{-7}	5.5×10^{-6}	1.1×10^{-5}	2.2×10^{-5}
Probability of landing in a town	5×10^{-4}	4.6×10^{-4}	1.6×10^{-3}	6.6×10^{-4}	2.0×10^{-3}	4.0×10^{-3}	8.1×10^{-3}
Probability of landing in the vicinity of the pipeline	1×10^{-5}	2.1×10^{-6}	Negligible	Negligible	2.1×10^{-6}	4.2×10^{-6}	8.4×10^{-6}
Total Risk: Nominal + Accident							
Probability of landing outside PFRR	1×10^{-2}	1.8×10^{-2} [f]	Negligible	Negligible	1.8×10^{-2}	3.5×10^{-2}	7.0×10^{-2}
Risk to individual members of the public	1×10^{-6}		1.57×10^{-6}		1.6×10^{-6}	3.1×10^{-6}	6.3×10^{-6}

a. PFRR risk criteria except individual criterion is specified in NASA Procedural Requirement **(NPR) 8715.5A**. The PFRR collective public risk criterion of 11.4×10^{-6} is more restrictive than the NASA Range Safety Manual **(NASA 2008)** criterion of 30×10^{-6} and the NPR 8715.5A criterion of 100×10^{-6}. See Chapter 3, Section 3.13, for more details.

b. Skees 2009, Lynch 40.023 Risk Assessment Rev. A 6/27/2011.

c. Skees 2010, 41.084 Risk Assessment 1/7/2010.

d. Skees 2011, Black Brant IX 35.256 Risk Assessment.

e. Mission casualty expectation is expected number of fatalities given a launch. It is estimated by evaluating the danger or lethal area represented by a rocket motor or payload impacting the ground and the density of people in the general impact area. The estimate includes the probability that a rocket fails in the case of accidents. This number is very small because the danger area would typically have a danger radius of only a few tens of meters.

f. The principal off-range area at risk of impact with the third stage of the Black Brant XII is Arctic National Wildlife Refuge and a small portion of Mollie Beattie Wilderness Area.

Comparison of PFRR Risks to the Public with Other Common Risks

The principal criterion imposed by NASA Procedural Requirements Range Safety Program **(NPR 8715.5A)** and NASA's *Range Safety Manual* **(NASA 2008)** is that the probability of a casualty among the potentially affected population must be less than or equal to 30×10^{-6} **(NASA 2008)** or 1 in 33,000, and 100×10^{-6} (**NPR 8715.5A)** or 1 in 10,000, over the course of the mission. This includes both normal launches and accidents, such as stages that do not ignite and motors with misdirected thrust and impact in unintended locations. The second basic criterion imposed by NASA is that the risk of casualty to any member of the public must be less than one in a million. These two types of criteria—one for the general population and one for individuals—are common across all U.S. rocket ranges, including those operated by NASA and the U.S. Department of Defense and those regulated by the Federal Aviation Administration. The criteria have their roots in public law. In 1949, Congress enacted Public Law 81-60 for establishment of a guided missile proving ground. The legislative history indicated, "From a safety standpoint [test flights of missiles] will be no more dangerous than conventional airplanes flying overhead" **(RCC 2002)**. The Range Safety Group compared individual and collective fatality risks to people on the ground from commercial aircraft and general aviation near commercial airports and casualty risks to the general public from military aircraft near several Air Force Bases. The Range Safety Group established common range safety criteria that met the intent of Congress **(RCC 2002, 2010)**. These criteria were then applied to current rocket test ranges, including those operated by and for NASA, including PFRR **(NPR 8715.5A)**.

The risks from PFRR operations on the public within the range are very small compared to the other risks that they face. Residents and visitors within the PFRR launch corridor face a number of other risks of accidents that could result in serious injuries or death. The remote nature of the area and the severe winter weather both contribute to injury and accidental death rates higher than many areas. Snow machine injuries and death rates in northern Alaska are among the highest in the country, with a death rate of 11 and hospitalization rate of 97 per 100,000 people in the 1993–1994 period **(Landen 1999)**. The death rate was comparable to automobiles and the hospitalization rate was twice that of on-road vehicles.

The serious injury and death rate among youth, ages 0–19 for rural, interior Alaska is also high. In the period from 1994–1998, the annual injury rate per 100,000 was 993, with 7 percent of the risk due to suicide, 15 percent due to falls, 4 percent due to motor vehicles, 7 percent due to snow machines, 6 percent due to sports, and 41 percent due to other activities **(Alaska 2001)**.

Among the approximately 1,500 residents within the PFRR area, this means that the annual individual risk of serious injury from snow machines alone is about 1 in 8,900 and the risk of accidental death is about 1 in 1,000. Among the youth in the region, the serious injury risk is even higher, about 1 in 1,000.

Other Potential Public Hazards with Normal Missions and Accidents

Fires **–** Spent stages are hot when they impact the ground and have the potential to start fires. However, launches primarily occur in the winter months and fires are not expected.

The propellant in motors that fail to ignite and return to Earth at high speed is likely to explosively detonate on ground impact, and again has the potential to start fires, but this is not expected as a result of the launches primarily occurring during the winter months.

Public Encounters with Payloads and Spent Stages – Members of the public have and are expected to continue to encounter spent payloads and spent stages in the field. The health and safety risks of these encounters should be very small unless an attempt is made to move, disassemble, or cut up the payloads or stages. Typical hazards associated with handling or disassembling payloads and spent stages include sharp or fractured metal associated with a damaged stage or payload; heavy objects; compressed springs; spent pyrotechnic devices;

charred materials, such as insulation, that might be an inhalation hazard in certain circumstances; and unique hazards that might be associated with a particular payload, such as pressurized containers. To avoid duplication, the potential hazards, and resulting risks, are presented in Section 4.12, Waste Management.

Sounding rocket motors, by their very nature, have explosive hazards, fire hazards, and stored energy hazards (such as compressed springs). If members of the public encountered an unspent stage before the NASA recovery team, they could face substantial risks if they attempted to handle, disassemble, or cut up the motor. A rocket motor that failed to fire or a payload containing explosive pyrotechnic devices or hazardous substances that did not function properly could be a substantial hazard. NASA would not leave any object on the ground that would pose a risk to anyone who might encounter it and would make all reasonable efforts to ensure that such motors are not a hazard to the public or the environment. It is for these reasons that NASA procedures call for quick actions following a mishap that might leave a failed rocket motor stage or payload in a hazardous condition. With this process in place, the likelihood of a member of the public encountering an unspent stage or a payload that could pose a substantial risk to a member of the public is low.

4.13.2.4 *Search and Recovery – Worker Health and Safety*

Initial search activities generally occur within a few days of the launch and would therefore most often occur during northern Alaska winter conditions. These extreme cold weather conditions present unique challenges and threats to the pilot and observers in the search plane during the initial, post-launch search activities. These personnel are required by NASA and UAF **(UAF 2011b)** to be adequately trained to perform their functions during these conditions. They would search for spent stages or payloads and mark their position, if found, as discussed in Appendix F.

Recovery teams would generally not be deployed until after the winter launch season and are expected to have a recovery plan for each recovery activity that would detail, among other things, the safety concerns and protocols associated with the specific recovery. Each payload or spent stage should have well-defined hazards, and the recovery team is expected to be fully aware of these hazards and to have appropriate equipment to deal with these hazards. Typical hazards include sharp or fractured metal associated with a damaged stage or payload; heavy objects; compressed springs; spent pyrotechnic devices; charred materials, such as insulation, that might be an inhalation hazard; and unique hazards that might be associated with a particular payload, such as pressurized containers. For some older rocket motor stages, the remaining insulation may contain asbestos materials embedded in resins that could present specific hazards **(Hesh 2011; Wilkie 1981)**. In all cases, the recovery plan is expected to identify all these hazards and present procedures for safe recovery by the team.

Once intact or damaged payloads or rocket motor stages or components are returned to PFRR, additional handling and disassembly and cleanup may be performed. As with the initial contact with these motors and stages in the field by the recovery team, worker hazards at the PFRR launch site would include sharp or fractured metal; heavy objects; charred materials that might be a inhalation hazard; and unique hazards that might be associated with a particular payload, such as pressurized containers. Some of the items recovered may be quite old, and detailed records of them may not be available. These operations would be conducted in accordance with

NASA and UAF environment, safety, and health procedures, including NASA WFF Occupational Safety & Health Manual requirements **(NASA 2006)**. Because these items can be unique and may not be well-characterized because of their age, it is expected that a job hazard analysis to identify the specific hazards and procedures to minimize risk to the workers and the environment would be performed prior to commencing work on a payload or stage. These types of analyses are required by the UAF PFRR Health and Safety Plan **(UAF 2011b)**.

4.13.2.5 *Search and Recovery – Failed Payloads and Stages*

Some payloads or stages may be recovered for safety reasons. An example might be a rocket motor that failed to fire or a payload containing explosive devices or hazardous substances that did not function properly. NASA would not want to leave any object on the ground that would pose a risk to anyone who might happen to come across it. Sounding rocket motors, by their very nature, have explosive hazards, fire hazards, and stored energy hazards (such as compressed springs). NASA would make all reasonable efforts to ensure that such motors are not a hazard to the public or the environment.

For rocket motor stages that do not ignite, it is likely that the impact forces would be sufficient that they ignite or detonate on impact with hard surfaces. For impacts on softer surfaces or water, it is possible that they may not detonate and would present a risk to the public. The recovery plan is expected to identify these possibilities and have detailed plans and procedures for their safe recovery as quickly as possible after a launch failure is confirmed.

A stage or payload that did not perform as expected could present other hazards. A failed rocket could result in the return to Earth of the payload containing the planned experiment. In some cases, the experimental materials may survive impact and present hazards to personnel encountering the payload or attempting to recover the payload. One type of common experiment at PFRR has a payload designed to release TMA (described in Chapter 2, Section 2.1.2.2, Chapter 3, Section 3.1.1, and Chapter 4, Section 4.2.2.2) in the upper atmosphere. This payload consists of two sections, one containing liquid TMA with a movable piston separating it from an area with high-pressure nitrogen. At altitude, an explosive valve is opened and the piston pushes the TMA into the atmosphere such that a long chemical trail is left behind.

On March 27, 2003, a T-IO rocket (41.028) was launched as part of a four-rocket experiment to study winds in the upper atmosphere, but the Orion motor failed. One of the four rocket motors did not thrust properly during its flight, causing it to fall short of its predicted altitude and land in a different part of the designated impact area than expected. It was found 9 kilometers (5.8 miles) north of the range in the ADNR Poker Flat North and South Special Use Areas. NASA wanted to study the rocket's remains to better understand the cause of the thrust failure. For safety purposes, NASA handled retrieval of the rocket as though it could be hazardous even though analysis indicated that the payload would not be dangerous. This safety precaution included having experts from the Air Force's Explosive Ordinance Disposal team puncture the payload's TMA canister before PFRR crews returned the second-stage motor and payload debris back to the range via helicopter for analysis. When the canister was punctured, there did not appear to be any TMA present **(GI 2003; Larsen 2001)**.

4.13.2.6 *Annual Worker Health and Safety Impacts*

Projected annual worker impacts were estimated for each stage of the search and recovery process, including flight time during the initial search for the payload and flight and helicopter times during the recovery process. Projected impacts were estimated based on the assumed times and workers required for each recovery task, together with established injury and fatality rates for similar types of activities. Specific risks of injury or death associated with time on the ground associated with digging up, disassembling, rigging, and other recovery activities were also estimated. Associated time at the PFRR launch site disassembling each payload or spent stage was also included. Table 4–33 summarizes the potential impacts of each of the proposed alternatives. Impacts were estimated for each of the options assuming four launches per year. With fewer or more launches, the impacts should scale proportionally. Similarly, the impacts would scale proportionally with more or fewer payloads or stages recovered. Under the No Action Alternative, it was assumed that only a single payload would be recovered annually and that the worker risks are small. Payloads are designed to be recovered with parachutes to reduce impact damage and facilitate recovery. An assumed 5-person recovery team is estimated to require 3 hours on the ground to recover the payload.

4.13.3 Alternative 1 – Environmentally Responsible Search and Recovery

4.13.3.1 *Rocket Launch Health and Safety*

Under Alternative 1, public and worker health and safety impacts associated with the launch of NASA SRP sounding rockets from PFRR would be the same as described under the No Action Alternative.

4.13.3.2 *Search and Recovery – Health and Safety*

Under Alternative 1, it was assumed that an average of two payloads and 10 stages would be attempted to be recovered annually. Accordingly, with less flight hardware within downrange lands, potential risks to the public would be smaller.

Although this alternative would result in a large number of fixed-wing and helicopter flight hours in the launch corridor, the worker risks should still be small (see Table 4–33). The estimated time on the ground for a 5-person recovery team under Alternative 1 is assumed to average 5 hours per stage. Projected impacts under Alternative 1 are about a factor of 6.4 to 9 times higher than the No Action recovery option, but are still small, with no lost work day injuries or fatalities expected during a year's recovery operations. Physically handling payloads and stages in remote areas with limited equipment is likely the most dangerous portion of the recovery team's activities. Rigging the payloads and stages and subsequent helicopter lifting is also a dangerous activity, but one in which the risks can be minimized with training and procedures.

4.13.4 Alternative 2 – Maximum Cleanup Search and Recovery

4.13.4.1 *Rocket Launch Health and Safety*

Under Alternative 2, launch-related public and worker health and safety impacts would be the same as described under the No Action Alternative.

4.13.4.2 *Search and Recovery –Health and Safety*

Under Alternative 2, it was assumed that an average of four payloads and 16 stages would be attempted to be recovered annually. Accordingly, with the least flight hardware within downrange lands, potential risks to the public would be the smallest of the alternatives. With proper recovery procedures and practices, the worker risks should still be small. Under Alternative 2, some of the stages are expected to be difficult to recover and require more time on the ground for the recovery team. The estimated time on the ground for a 5-person recovery team under Alternative 2 is assumed to average 10 hours for stages. Projected impacts of Alternative 2 are about a factor of 11 to 19 times higher than the No Action Alternative. Even so, the likelihood of a lost-work-day injury over a year among the recovery team is low, as shown in Table 4–33.

4.13.5 Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories

Worker and public health and safety impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.13.3, with the exception of NASA’s restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not greatly change the potential health and safety risks associated with this alternative compared to those described for Alternative 1.

4.13.6 Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories

Worker and public health and safety impacts under Alternative 3 would be identical to those identified under Alternative 2 in Section 4.13.4, with the exception of NASA’s restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not greatly change the potential health and safety risks associated with this alternative compared to those described for Alternative 2.

4.13.7 Summary of the Alternatives

This section includes several tables to provide the reader a concise comparison of the estimated safety risks resulting from launch and recovery of SRP rockets and payloads on a per-year basis.

Table 4–33 presents the risk estimates and probabilities from the flight safety risk assessments from recent BB XII and T-IO missions, along with projected annual future risks with two, four, and eight launches per year with a 50-50 split of the two launch vehicles. As the proposed number of future launches is the same for all alternatives, this table is applicable to them all.

Table 4–34 summarizes the potential impacts on worker safety resulting from each of the alternatives under consideration.

Table 4–34. Projected Annual Worker Safety Impacts of Recovery Operations

Annual Impact Area	No Action Alternative	Alternatives 1 and 3	Alternatives 2 and 4
Recoveries per year, assuming 4 launches per year	1 payload, 0 stages	2 payloads, 10 stages	4 payloads, 16 stages
Projected number of fatal and serious injury flight accidents[a]	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}
Total annual occupational injuries during ground recovery activities[b]	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}
Total annual occupational fatalities during ground recovery activities[c]	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}

a. Based on Federal Aviation Administration accident rates for general aviation in Alaska in 2010 **(FAA 2011)**.
b. Based on U.S. Bureau of Labor statistics estimates of injuries that require days away from work **(BLS 2011b)**.
c. Based on U.S. Bureau of Labor statistics estimates of fatal work injuries **(BLS 2011a)**.

Table 4–35 summarizes the projected health and safety impacts on the public and PFRR workers for each of the alternatives considered. Projected launch impacts are based on an annual average of four launches per year, which, for analysis purposes, was assumed to be an equal mix of BB XII and T-IO launch vehicles.

Table 4–35. Projected Annual Impacts on the Public and Workers

	PFRR Mission Risk Criteria[a]	Normal Launch			Restricted Flight Trajectories		
		No Action Recovery	Alternative 1	Alternative 2	No Action Recovery	Alternative 3	Alternative 4
Annual Public Risk from Four PFRR launches per year:							
Risk of a casualty among members of the public[b]	1.1×10^{-5}	5.5×10^{-6}	1.1×10^{-5}	2.2×10^{-5}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing in a town	5×10^{-4}	2.0×10^{-3}	4.0×10^{-3}	8.1×10^{-3}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing in the vicinity of the pipeline	1×10^{-5}	2.1×10^{-6}	4.2×10^{-6}	8.4×10^{-6}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Probability of landing outside PFRR[c]	1×10^{-2}	1.8×10^{-2}	3.5×10^{-2}	7.0×10^{-2}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2
Risk to individual members of the public							
	1×10^{-6}	1.6×10^{-6}	3.1×10^{-6}	6.3×10^{-6}	Similar to Normal Launch–No Action	Similar to Normal Launch–Alternative 1	Similar to Normal Launch–Alternative 2

Table 4–35. Projected Annual Impacts on the Public and Workers (*continued*)

	PFRR Mission Risk Criteria[a]	Normal Launch			Restricted Flight Trajectories		
		No Action Recovery	Alternative 1	Alternative 2	No Action Recovery	Alternative 3	Alternative 4
Annual risk to PFRR workers and recovery personnel with annual recoveries of:							
Projected number of fatal and serious injury flight accidents	N/A	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}	3.5×10^{-4}	2.2×10^{-3}	3.7×10^{-3}
Total annual occupational injuries	N/A	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}	3.6×10^{-3}	3.1×10^{-2}	6.2×10^{-2}
Total annual occupational fatalities[d]	N/A	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}	4.1×10^{-5}	3.7×10^{-4}	7.9×10^{-4}

a. PFRR risk criteria except individual criterion is specified in NASA Procedural Requirement **(NPR) 8715.5A**. The PFRR collective public risk criterion of 11.4×10^{-6} is more restrictive than the NASA *Range Safety Manual* **(NASA 2008)** criterion of 30×10^{-6} and the **NPR 8715.5A** criterion of 100×10^{-6}. See Chapter 3, Section 3.13, for more details.

b. Mission casualty expectation is expected number of fatalities given a launch. It is estimated by evaluating the danger or lethal area represented by a rocket motor or payload impacting the ground and the density of people in the general impact area. The estimate includes the probability that a rocket fails in the case of accidents. This number is very small because the danger area would typically have a danger radius of only a few tens of meters.

c. The principal off-range area at risk of impact with the third stage of the Black Brant XII includes a portion of Arctic National Wildlife Refuge and a small portion of Mollie Beattie Wilderness Area.

d. The major contributor to public risk from accidents is a failed motor impacting near the U.S. Bureau of Land Management Crowberry cabin, which is assumed to be occupied **(Skees 2009, 2010)**.

4.13.8 Summer Launches

The potential population risks would be higher for summer launches due to higher population densities and greater potential for unintended impacts due to accidents, including fires started by incompletely burned stages. The NASA SRP would likely have to establish mandatory clear zones or accept a higher risk with a summer launch. Areas that are not normally populated during winter launches might see substantially higher risks if they are in the predicted impact areas.

Burning solid propellant and hot rocket motors could produce fires in areas of impact. This would be especially true where impacts occurred in dry areas during the summer months. As part of the PFRR safety efforts, an emergency response plan would be developed for launches in non-winter periods, which will address the requirements for responding to fires caused by PFRR operations. Since the probability of impact at any given location is remote, it would be unfeasible to pre-position fire-fighting equipment. As such, agencies landowners of the potentially impacted areas would be notified of upcoming PFRR flights and appropriate plans would be developed.

PFRR would assume primary responsibility for investigation of the impact site and recovery of flight hardware. The Alaska Fire Service would likely provide the primary firefighting force depending on the land ownership. The hazards to these firefighting crews would only be those normally associated with wilderness fire fighting since burning solid fuels and other potentially dangerous materials would be consumed before a response force could arrive on the scene.

Since PFRR and coordinating agencies would act to fight any fires resulting from rocket mishaps it is assumed that and would undertake debris recovery operations, safety impacts of secondary effects of debris impact are considered to be small.

The potential worker risks would be unchanged or slightly less for summer launches because workers would not be subject to the below freezing temperatures present at PFRR during the winter months. The potential public risks would be greater for summer launches because more people would likely be recreating in areas of the PFRR where payloads and spent stages could impact. Before scheduling a summer launch, additional safety analyses would need to be performed to ensure that such launches could be conducted safely in accordance with NASA and UAF guidelines.

4.14 SOCIOECONOMICS AND ENVIRONMENTAL JUSTICE

4.14.1 Socioeconomics

This section presents the potential socioeconomic impacts from PFRR operations and search and recovery activities under the proposed alternatives. Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The ROI for the socioeconomic environment includes the geographic area that supplies the majority of inputs for an activity. As discussed in Chapter 3, the majority of PFRR employees reside in Fairbanks North Star Borough. Therefore, the Fairbanks North Star Borough is the ROI for this socioeconomic analysis. Economic impacts are estimated using the Regional Input-Output Modeling System (RIMS II) developed by the Bureau of Economic Analysis (BEA) **(BEA 2011)**. BEA RIMS II multipliers use a combination of national and regional data to estimate the potential economic impacts of an industry's activity on other industries within the ROI that supplies resources to that industry. Multipliers are provided to estimate impacts on economic output, earnings, employment and value added. Impacts from normal operations at PFRR were estimated using multipliers for the "scientific research and development services" industry, impacts from annual maintenance activity were estimated using multipliers from the "commercial and industrial machinery and equipment repair and maintenance" industry, impacts from search and recovery operations were estimated using multipliers for the "air transportation" industry, and impacts related to the accommodative services needed for temporary personnel visiting for launch activities are estimated using multipliers for the "hotels and motels" and "food services and drinking places" industries. The direct requirements of labor and resources under each alternative were used to estimate the potential impacts in terms of employment, economic output, earnings, and value added from PFRR activities, as well as the resulting indirect impacts within the ROI. Employment impacts are evaluated in terms of the potential impact to the regional work force from the alternatives. Impacts from economic output are evaluated using the value added to the regional economy in terms of final goods and services directly comparable to gross domestic product (GDP). GDP is a widely used indicator of economic activity that represents the final value of all goods and services.

Impacts are considered minor if they are determined to account for less than 1 percent of the evaluation criteria for that resource. Similarly, impacts between 1 and 5 percent are considered to be moderate and impacts greater than 5 percent are considered major. Impacts determined to be immeasurable are considered negligible. The duration of the impacts would be considered short-term if they were to last for less than 1 year. Impacts would be considered medium-term if they would persist throughout the period where NASA SRP would continue to launch from PFRR and come to an end if the NASA SRP discontinued launching from PFRR. Impacts would be considered long-term if the impact persists after the NASA SRP discontinued launching from PFRR.

4.14.1.1 *No Action Alternative*

Launch Operations

Minor, beneficial socioeconomic impacts estimated under the No Action Alternative as a result of continued PFRR operations are expected to be medium-term. **Table 4–36** displays the estimated economic impacts attributable to PFRR activities under the No Action Alternative.

Table 4–36. Estimated Economic Impacts from PFRR Operations by Activity

Annual Impacts (2010 Dollars)	Direct Economic Output	Value Added	Direct Earnings	Indirect Earnings
Normal Operations	$1,900,000	$1,900,000	$1,400,000	$640,000
Launch Activities	$310,000	$300,000	$210,000	$100,000
Maintenance Activities	$160,000	$150,000	$52,000	$24,000
Total	$2,400,000	$2,300,000	$1,600,000	$800,000

Normal operations at PFRR are estimated to result in direct employment of approximately 17 full-time equivalents annually. Direct employment at PFRR is expected to generate indirect employment of approximately 11 jobs, for a total impact of 28 jobs within the ROI attributable to PFRR activities. Normal operations at PFRR are estimated to generate approximately $1.9 million of direct economic activity annually. It is estimated that approximately 97 percent of the direct economic activity is value added to the local economy in terms directly comparable to GDP. The value added from PFRR operations accounts for less than one-tenth of 1 percent of the total GDP, and approximately 1.3 percent of the professional, scientific, and technical services industry GDP for the Fairbanks area of Alaska. Approximately $1.4 million of the value added would be in the form of earnings to PFRR employees, which in turn would generate an estimated $640,000 of indirect earnings within the ROI.

Several times a year, the number of people engaged in PFRR operations increases to support launch and maintenance activities. It is estimated that launches would occur, on average, four times per year under the No Action Alternative. During launch periods, visiting personnel are estimated to reach up to 35 people at any given time. Maintenance activities occur for a 3-week period annually during the summer and require approximately 15 additional workers. Due to their temporary nature, these launch and maintenance activities are expected to generate up to two additional full-time jobs within the ROI. Per diem spending on lodging, meals, and incidentals for visiting and payload personnel would create additional beneficial impacts. It is estimated that an additional 5 full-time jobs can be attributed to per diem spending. Additional direct economic output attributable to launch and maintenance activities is estimated to be approximately $0.5 million annually.

Search and Recovery

Under the No Action Alternative, the level of search and recovery activity at PFRR would continue as it has in the past. It is assumed that one payload would be attempted to be recovered annually. Search and recovery activities under the No Action Alternative would result in negligible, though beneficial, impacts over the medium-term. Approximately $20,500 of direct economic output would be generated during recovery. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $18,000. Search and recovery activities under the No Action Alternative are not expected to create any additional indirect employment opportunities in the ROI.

4.14.1.2 *Alternative 1 – Environmentally Responsible Search and Recovery*

Launch Operations

NASA launches and PFRR operations under Alternative 1 would be the same as those described above under the No Action Alternative. Therefore, impacts on employment, earnings, output, and value added under Alternative 1 would be identical to those described under the No Action Alternative.

Search and Recovery

Under Alternative 1, it is assumed that two payloads and 10 spent stages would be recovered annually. Search and recovery activities under this alternative are expected to result in minor, though beneficial, economic impacts over the medium-term. Approximately $190,000 of direct economic output would be generated during search and recovery operations. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $166,000. Search and recovery activities under Alternative 1 are estimated to generate up to three additional full-time jobs in the ROI.

4.14.1.3 *Alternative 2 – Maximum Cleanup Search and Recovery*

Launch Operations

NASA launches and PFRR operations under Alternative 2 would be the same as those described above under the No Action Alternative and Alternative 1. Therefore, impacts on employment, earnings, output, and value added under Alternative 2 would be identical to those described under the No Action Alternative.

Search and Recovery

Under Alternative 2, it is assumed that four payloads and 16 spent stages would be attempted to be recovered annually. Search and recovery activities under this alternative are expected to result in minor, though beneficial economic impacts over the medium-term. Approximately $321,000 of direct economic output would be generated during search and recovery operations. The value added to the local economy in terms of final goods and services directly comparable to GDP is estimated to be approximately $282,000. Search and recovery activities under Alternative 2 are estimated to generate up to four additional full-time jobs in the ROI.

4.14.1.4 *Alternative 3 – Environmentally Responsible Search and Recovery with Restricted Trajectories*

Socioeconomic impacts under Alternative 3 would be identical to those identified under Alternative 1 in Section 4.14.1.2, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential socioeconomic impacts associated with this alternative compared to those described for Alternative 1.

4.14.1.5 *Alternative 4 – Maximum Cleanup Search and Recovery with Restricted Trajectories*

Socioeconomic impacts under Alternative 4 would be identical to those identified under Alternative 2 in Section 4.14.1.3, with the exception of NASA's restricting trajectories on future launches such that designated Wild and Scenic River segments or Wilderness Areas would not be allowed to have predicted impact points for stages or payloads within them. These restricted trajectories would not change the potential socioeconomic impacts associated with this alternative compared to those described for Alternative 2.

4.14.2 Summer Launches

Summer launches would not change the socioeconomic impacts projected for the different alternatives under consideration. The same number of people would be needed to support the launches and search and recovery activities regardless of whether they occurred during the winter or summer.

4.14.3 Environmental Justice

This section addresses the potential for the proposed alternatives to result in disproportionately high and adverse impacts on minority and low-income populations. The criteria for evaluation of environmental justice impacts are based on the impacts identified for the various resource areas analyzed throughout this EIS. The intensity and duration of the impacts presented in this section are consistent with those defined under each resource area. Wherever adverse impacts on offsite populations are identified, further evaluations are considered to determine whether those impacts would disproportionately affect minority and low-income populations. Due to the nature of operations at PFRR, impacts from launch and search and recovery operations would result in little to no adverse impacts on offsite populations for the majority of resource areas. Potential human health impacts from PFRR operations and transportation and impacts on subsistence users within PFRR as a result of normal operations and accidents are the primary concerns likely to have the potential to adversely impact offsite populations.

Potential human health impacts on offsite populations from normal launch operations are discussed in Section 4.13. This analysis determined that the risk of a casualty to offsite populations would be negligible and medium-term. Safety policies and practices at PFRR are designed to protect populations and minimize the risk of impacts on human life, property, and natural resources within the PFRR launch corridor. UAF has agreements in place with two villages (Venetie, Arctic Village) regarding the use of tribal lands for research purposes. These agreements secure permission for potential impact areas on tribal lands. Additionally, NASA and UAF have designed programs that use monetary incentives to help locate and retrieve spent stages and payloads, providing opportunities for native populations to benefit economically (see Appendix E).

Potential impacts on offsite populations from off-normal flights and accidents are discussed in Section 4.13.2.2. This analysis determined that the risk of a casualty to offsite populations would be negligible to minor, and medium-term for all accident scenarios.

Sections 4.13.5 and 4.13.6 discuss the potential impacts on human health due to utilizing alternate flight zones. Alternate flight zones are designed to avoid impacting environmentally sensitive areas. Current practice is to minimize impacts on human health by avoiding populated places. Avoidance of environmentally sensitive areas could result in the potential impact areas being in closer proximity to populations. Under such a scenario, the probability of spent stages impacting offsite populations would increase when compared to the flight zones currently in use; however, the analysis determined that the overall risk to offsite populations remains negligible to minor, and medium-term.

As described in Section 4.10, any adverse impacts on subsistence resources or the harvest of subsistence resources are expected to be minor and short-term in duration under any of the alternatives. Similarly, transportation impacts are projected to be negligible under any of the alternatives, as discussed in Section 4.11.

Section 4.3 discusses the potential impacts on water resources. Any adverse impacts on surface water and groundwater under any alternatives are expected to be short-term and negligible.

Section 4.5 discusses the potential noise impacts from launch and recovery operations. Adverse impacts from launch operations under any of the alternatives would be short-term and moderate. Adverse impacts from search and recovery operations under any of the alternatives would be medium-term and moderate.

Section 4.6 discusses potential impacts on visual resources. Minor impacts to visual resources within the PFRR launch corridor are expected from launch and recovery operations under any of the alternatives. Impacts to visual resources may be short-term or long-term depending on how long the payload or spent stage is left unrecovered and how often the flight hardware is viewed by users of the areas within the launch corridor.

Section 4.12 discusses the potential impacts from hazardous materials and hazardous waste. Any potentially adverse impacts under any of the alternatives would be temporary and minor. Alternatives 2 and 4 that involve increased recovery scenarios would have a temporary minor beneficial impact.

As described in Chapter 3, Section 3.14, the downrange population primarily consists of minority and low-income communities. However, the analysis presented throughout Chapter 4 has shown the intensity of the risks to public health and safety from NASA SRP normal operations, off-normal flights, postulated accidents, and transportation are estimated to be negligible to minor. In addition, continued SRP operations at PFRR, including search and recovery activities, are not expected to adversely affect subsistence resources or users within the PFRR launch corridor.

Therefore, continued NASA SRP operations at PFRR are not expected to result in disproportionately high and adverse impacts on minority or low-income populations under any of the alternatives under consideration in this *Draft PFRR EIS*.

4.15 CUMULATIVE EFFECTS

CEQ regulations define cumulative effects as effects on the environment that result from implementing one of the alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions **(40 CFR 1508.7)**. Cumulative effects can result from individually minor but collectively significant actions taken over a period of time. Cumulative effects can also result from spatial (geographic) and/or temporal (time) crowding of environmental disturbances (*i.e.,* concurrent human activities and the resulting effects on the environment are additive if there is insufficient time for the environment to recover).

4.15.1 Geographic Extent of Cumulative Effects Analysis

The geographic extent of the cumulative effects analysis includes the area within the PFRR launch corridor and the area surrounding the Alaska Pipeline Project (see Section 4.15.2) located directly west of the PFRR launch corridor. The location of the areas included in the cumulative effects analysis is shown in **Figure 4–20**. Located within the PFRR launch corridor are landmasses owned by the U.S. government, Alaska Native organizations and villages, the State of Alaska, and private landowners.

4.15.2 Temporal Extent of Cumulative Effects Analysis

The temporal extent begins with the initiation of the PFRR (circa 1968) up through 10 years into the future (*i.e.,* 2023).

4.15.3 Specific Actions Within the Poker Flat Research Range Launch Corridor

The sections below describe the past, present, and reasonably foreseeable future actions within the PFRR launch corridor that NASA considered in its cumulative effects analysis. The sequence in which the actions are discussed is related to geographic location, starting at the PFRR launch site and moving north up to the Beaufort Sea/Arctic Ocean.

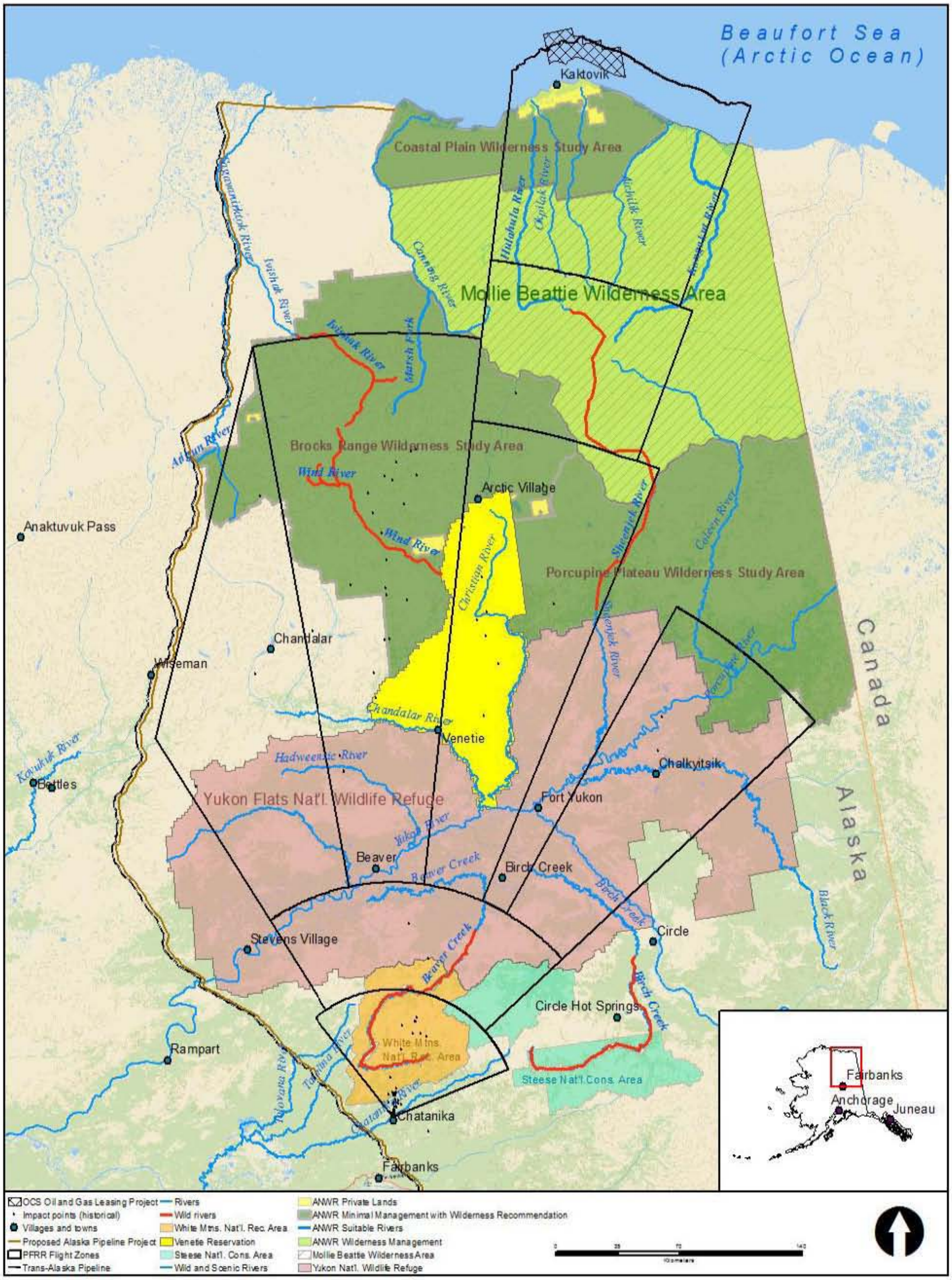


Figure 4–20. Activities Included Within Cumulative Effects Analysis

4.15.3.1 *Poker Flat Research Range Past Launches 1968–Present*

As discussed in Chapter 2, NASA has been launching sounding rockets from PFRR for over 40 years. During that time, 219 NASA launches have been conducted. In addition to the NASA launches, PFRR has enabled 116 launches in support of other agencies, primarily the U.S. Department of Defense and National Science Foundation. No non-NASA-sponsored launches have flown from PFRR since 1995. In support of these launches, latex balloons and small test rockets have been launched routinely during countdowns to obtain upper atmospheric weather data and calibrate radar systems, respectively. In addition to the relatively larger sounding rocket launches summarized above, the U.S. Army launched a standard meteorological balloon and rocket (Loki/Super Loki-Dart) from PFRR three times per week between approximately 1971 and 1979.

4.15.3.2 *Eastern Interior Resource Management Plan*

BLM is developing a Resource Management Plan (RMP) for its Eastern Interior Planning Area. The RMP will provide future direction for 2.7 million hectares (6.7 million acres) of public land including the White Mountains NRA, the Steese NCA, and the Forty-mile area near Chicken and Eagle, Alaska. Resource management plans provide BLM with long-term direction regarding the use and management of resources on its managed public lands. The RMP will establish goals and objectives for managing resources, and it will outline the measures needed to achieve those goals and objectives. It will identify lands available for certain uses, along with any restrictions on those uses, and will identify lands closed to certain uses. The draft RMP was released in February 2012 for public review.

4.15.3.3 *Interior Oil and Gas Exploration*

Oil and gas exploration has been conducted in the Yukon Flats area since 1954 and has consisted of airborne magnetometer surveys, seismic surveys, well drilling, and borings. Past surveys resulted in the clearing of an estimated 174 hectares (430 acres) of vegetation; these areas are generally located between the Villages of Beaver and Chalkyitsik. The other surveys were conducted in the water, along roads, or via helicopter. Some of the survey lines are currently used as transportation and/or trapping routes. No development or production of oil and gas has occurred to date in Yukon Flats NWR **(USFWS 2010a)**.

Winter seismic exploration was conducted on the coastal plain of the Arctic NWR in 1984 and 1985. Approximately 2,000 kilometer (1,240 miles) of seismic lines, arranged in a grid pattern, were completed between January and May of both years. Collection of data along each seismic line required multiple passes by tracked vehicles. Ski-mounted camps pulled by tractors created a second series of trails **(Raynolds and Felix 1989)**. Some of the trails created by this effort are still visible today **(USFWS 2012)**.

Oil exploration and development could be expected to occur in the future on private lands within the ROI as there are approximately 405,000 hectares (1 million acres) of land under private ownership within the Yukon Flats NWR identified as having the potential for such resources. Gas development is not expected to occur on these lands in the reasonably foreseeable future due to the lack of infrastructure to transport gas to market, along which a gas line might be constructed. In its 2010 *Land Exchange EIS,* USFWS estimated that land disturbance from establishing rights-of-way associated with selected future activities could range in size from 162 to 688 hectares (400 to 1,700 acres) per right-of-way **(USFWS 2010a)**.

Doyon, Limited is actively sponsoring new oil and gas exploration near Stevens Village in the Yukon Flats Basin. Two-dimensional seismic, land and airborne gravity, and geochemical surveys have been ongoing and will likely continue into the reasonably foreseeable future. Exploration wells may be constructed within the next several years. Access to these areas for data collection efforts would be via helicopter and snow machine.

4.15.3.4 *Chandalar Mining District*

Located approximately 310 kilometers (190 miles) north of Fairbanks, the Chandalar Gold District (District) consists of four hard-rock and 7 historic mines on approximately 9,300 hectares (23,000 acres). In addition, the company that has mining rights within the District has identified 28 prospects in the area that could be mined in the future. There is presently no all-weather road access; however, four airstrips within the claim boundaries accommodate air access to the 25-person camp. Seasonal overland access is from Coldfoot via a 90-kilometer-long (55-mile-long) winter trail to the state airport at Chandalar Lake. All major prospects within the district are connected via a 45-kilometer-long (28-mile-long) network of access roads.

4.15.3.5 *Burnt Mountain Seismic Observatory*

The U.S. Air Force operates an unattended seismic observatory station on an approximately 40-hectare (100-acre) parcel in the Burnt Mountain area to help verify compliance with nuclear test ban treaties. The principal equipment at Burnt Mountain consists of borehole seismometers to collect the seismic data and a radio to communicate the data off site for analysis. There are five seismometers clustered within a 2-kilometer (1.5-mile) radius and linked to a central communications station via surface-laid data cable.

The station is located along the boundary of Arctic and Yukon Flats NWRs in a remote area about 80 kilometers (50 miles) from the closest villages (Venetie, Arctic Village, and Chalkyitsik). All personnel and materials are flown in from Fort Yukon via helicopter. On average, there are approximately six personnel visits a year for the purposes of maintenance and inspection.

4.15.3.6 *Arctic National Wildlife Refuge Revised Comprehensive Conservation Plan*

In August 2011, USFWS published the *Arctic Refuge Draft Revised Comprehensive Conservation Plan (Draft Revised Arctic CCP)* **(USFWS 2011c)**. Once complete, the Arctic CCP will provide management direction for Arctic NWR for the next 15 years. USFWS is evaluating six alternatives in the *Draft Revised Arctic CCP*, including designation of additional areas within Arctic NWR to be managed as Wilderness, Wild River, and minimal management areas **(USFWS 2011c)**. Many of these potentially designated areas are within the PFRR launch corridor.

4.15.3.7 *State of Alaska Sale of North Slope Leases*

On December 7, 2011, ADNR issued a Notice of Sale for 3,145 tracts of State land ranging in size from 260 to 2,330 hectares (640 to 5,760 acres) in the Beaufort Sea, the North Slope, and the North Slope Foothills areas. These leases allow for the possibility of oil and gas exploration and development in the areas adjacent to Arctic NWR. The sale resulted in a preliminary sale of 178 tracts (135,600 total hectares [334,969 total acres]). Of those tracts sold, 34, or 44,300 hectares (109,440 acres), were between the Arctic NWR boundary and the existing Trans-Alaska Pipeline. Three tracts (734, 740, and 743) are adjacent to the Arctic NWR boundary, and the Canning River constitutes the easternmost boundary of tract (743).

4.15.3.8 *Long-Range Transportation Plan*

In 2009, the Alaska Department of Transportation and Public Facilities undertook an effort to develop a multi-agency transportation plan. Still in its early stages of development, the plan's objective is to identify and prioritize transportation improvements on Federal lands in the State of Alaska. Along with the Alaska Department of Transportation and Public Facilities, the following Federal agencies are involved: National Park Service, USFWS, BLM U.S. Forest Service, and the Federal Highway Administration's Western Federal Lands Highway Division. The plan will not seek to identify specific projects or suggest changes to Federal lands management. Instead, its intent is to serve as a tool to collectively engage agencies on how to work together and leverage funding. The Long-Range Transportation Plan consists of two parts: (1) an overarching plan addressing common objectives among the agencies, and (2) "dropdown" plans specific to each agency to address individual transportation needs.

4.15.3.9 *Polar Bear Conservation Plan*

USFWS is in the early planning stage of developing the Polar Bear Conservation Plan (Plan). Polar bears were listed under the ESA on May 15, 2008. The ESA and the Marine Mammal Protection Act require USFWS to develop a recovery plan and a conservation plan, respectively, to identify and implement future conservation, management, and research activities. USFWS has determined that the Plan will identify threats to polar bears, identify action items to address those threats and involve partners in the process of development and implementation. The intent of the Plan is to guide management and research activities now and into the future; it is scheduled to be completed in the fall/winter of 2013 **(USFWS 2012)**.

4.15.3.10 *Barter Island Airport Improvement Project*

The existing Barter Island Airport is in Arctic NWR and is located on a gravel spit extending from the northeast corner of Barter Island. The airport provides the only year-round access to the community of Kaktovik, Alaska. The FAA and North Slope Borough plan to relocate the airport to the south side of Barter Island, about 1 mile southwest of Kaktovik, onto lands owned by the Kaktovik Iñupiat Corporation.

4.15.3.11 *Barter Island Distant Early Warning-Line Cleanup*

The Barter Island Distant Early Warning-Line (DEW-Line) is an integrated chain of radar and communications sites stretching across Alaska, northern Canada and Greenland. Its purpose was to detect any incoming, over-the-pole, aircraft invasions emanating from the Soviet Union.

The program was discontinued in 1963 and most sites were closed at that time. Cleanup of the stations occurred in the late 1990s and continues today. Many of the sites had contaminated soils or expected contamination consisting of petroleum, lubricants, polychlorinated biphenyls, and insecticides, along with considerable volumes of debris and general refuse.

The Barter Island DEW-Line station consists of 14 determined Installation Restoration Program sites, many of which have undergone building/structure demolition and disposal and environmental background sampling.

4.15.3.12 *Beaufort Sea Planning Area*

In November 2011, the USDOI released the *Outer Continental Shelf Oil and Gas Leasing Program: 2012–2017 Draft Programmatic Environmental Impact Statement (OCS Oil and Gas Draft PEIS)* **(USDOI 2011e)** for public review. In the *OCS Oil and Gas Draft PEIS*, USDOI is evaluating the impacts of holding lease sales in six of the Outer Continental Shelf (OCS) Planning Areas in the Gulf of Mexico and offshore Alaska from 2012–2017. USDOI analyzed the impacts associated with eight alternatives that would occur associated with lease sales located in the Central, Western, and Eastern Gulf of Mexico, the Beaufort Sea, the Chukchi Sea, and the Cook Inlet Planning Areas. Under seven of the eight alternatives, the Beaufort Sea Planning Area would be included in the lease sales. Under Alternative 5, the Beaufort Sea Planning Area would be excluded from the lease sales.

4.15.4 Specific Actions Outside of the Poker Flat Research Range Launch Corridor

4.15.4.1 *Gold Mining at Livengood*

A Canadian mining company is currently pursuing the establishment of a large gold mine on a 20,000-hectare (50,000-acre) site known as “Money Knob” in the Livengood Mining District. Depending on the season, between approximately 50 and 125 personnel are currently involved in exploratory activities, with the staging area for those operations at an old Elliott Highway pipeline construction camp near the prospect. Since 2006, more than 700 exploration-related boreholes have been drilled as part of the project.

Located approximately 110 kilometers (70 miles) north of Fairbanks, the open pit mine is not expected to begin work any sooner than 2018 and would have an expected 23-year life once operational. To extract the recoverable portion of the gold, the material would be hauled away, crushed in a mill and ground to a consistency that allows the gold to be removed.

If the mine proceeds, it is estimated that up to 1,100 people would be employed during a several-year-long construction phase. Once operational, an estimated 500 people would work at the mine.

4.15.4.2 *Dalton Highway Scenic Partnership Plan*

The Dalton Highway Scenic Byway Corridor Partnership Plan was completed in March 2010. It is a comprehensive evaluation of the byway's intrinsic qualities; it also serves as a guide for management, protection, and enhancement of present and future intrinsic qualities. The plan was developed by ADNR to designate the highway as a National Scenic Byway. The overall mission of the plan is "to act as a collective voice for all byway stakeholders in order to address concerns relating to current and future uses, management actions, and developments in the Dalton Highway corridor and to preserve, protect, and enhance the byway's intrinsic qualities...for the benefit of current and future travelers" **(USFWS 2012)**.

4.15.4.3 *Foothills West Transportation Access Project*

The Foothills West Transportation Access Project (commonly referred to as the "Foothills Project" or "Umiat Road Project") includes construction of an all-season gravel road from Dalton Highway to Umiat, Alaska. The purpose of the Foothills Project is to provide access to oil and gas resources both along the northwestern foothills of the Brooks Range and in the National Petroleum Reserve-Alaska. The U.S. Army Corps of Engineers is currently preparing an EIS for the proposed project. The U.S. Army Corps of Engineers expects to release the draft EIS in the fall 2013; the Record of Decision is expected to be published by winter 2014.

4.15.4.4 *Alaska Pipeline Project*

The Alaska Pipeline Project involves construction of two additional oil pipelines and one additional gas pipeline from Point Thompson, Alaska, to Prudhoe Bay, Alaska. The two additional oil pipelines would be constructed from Prudhoe Bay, Alaska, to Valdez, Alaska, and from Prudhoe Bay, Alaska, to Caroline, Alberta. These pipelines would follow the existing Trans-Alaska Pipeline from Prudhoe Bay to Fairbanks, where one would continue following the Trans-Alaska Pipeline to Valdez and the other would continue on to Caroline in Alberta, Canada. The additional gas pipeline would be constructed from Prudhoe Bay east to Point Thompson. A new gas treatment plant would also be constructed near Prudhoe Bay to prepare the gas for pipeline transport. Once completed, the pipelines would have a total length of 4,200 kilometers (2,600 miles) and capacity to handle 250 million cubic meters (8.9 billion cubic feet) of oil per day and 31 million cubic meters (1.1 billion cubic feet) of natural gas per day **(TransCanada 2011)**.

4.15.5 General Actions Considered for Cumulative Effects

The sections below present several general categories of recurring actions occurring within and adjacent to the PFRR launch corridor that NASA considered in its cumulative effects analysis.

4.15.5.1 *Land Management, Research, and Monitoring*

It is expected that activities inherent in land management, including law enforcement, biological survey, and wildland fire monitoring, will continue on Federal, state, and Native lands as they have in the recent past. Remote areas will continue to be accessed by fixed-wing aircraft, helicopters, boats, and snowmobiles, depending on season and the type of activity undertaken.

4.15.5.2 *Recreational Use*

Recreational uses of downrange lands include riding OHVs, hiking, river floating, fishing, hunting, and camping during non-winter months. Winter uses primarily include trapping, cross-country skiing, and snowmobiling. Based upon recent trends, the two primary Federal land management agencies within the PFRR launch corridor expect demands for recreation to increase in the next 10 years **(USDOI 2012a; USFWS 2012)**.

4.15.5.3 *Placer Mining*

Placer mining refers to removing precious metal deposits found in alluvial deposits, which are deposits of sand and gravel in modern or ancient stream beds. Since its first discovery within the southern portion of the launch corridor in the late 1800s, gold mining has occurred ever since **(USDOI 2012a)**.

4.15.6 Methodology

4.15.6.1 *Overview*

The cumulative effects analysis for this *Draft PFRR EIS* involved combining the impacts of the proposed alternatives on each resource area with the impacts of other past, present and reasonably foreseeable activities within the ROI. The general approach to the analysis involved the following process:

- Identify baseline impacts from past and present actions (*i.e.,* the baseline conditions described in Chapter 3).
- Identify potential impacts produced by the continued launch and search and recovery of NASA sounding rockets from PFRR (as described in Sections 4.1 through 4.14).
- Identify potential impacts associated with the actions described in Sections 4.15.1 and 4.15.2.

For each resource area, the impact descriptors (*e.g.,* type, intensity, duration) presented correspond directly to those established for the assessment of direct and indirect impacts in earlier sections of this EIS. Rather than repeating the impact descriptor definitions in this section, should the reader desire to learn what would constitute a particular impact on a resource area, he/she is directed to the respective methodology presented for that resource.

4.15.6.2 *Unavailable Information*

CEQ regulations **(40 CFR 1502.22)** require that Federal agencies clearly identify when information having a bearing on either significant environmental impacts or choice among alternatives is either incomplete or unavailable. During the scoping period for this EIS, the most substantial cumulative effect-related concern raised by members of the public focused on the quantity and location of previously launched flight hardware. As such, during the preparation of this *Draft PFRR EIS*, NASA and UAF researched known sources of information, including post-mission summary reports and flight safety plans, and held discussions with former PFRR employees; however, it has been concluded that impact location data for all past sounding rockets launched from PFRR are not available. Due primarily to personnel changes and a historically lower emphasis on the downrange location of items, such information has not been maintained at either the PFRR launch site or within the NASA SRP. Of particular note is a large records disposal that occurred at PFRR sometime in the 1990s **(Brown 2012)**. Pre-1990 NASA and all non-NASA launch data are particularly scarce.

Therefore, in the absence of complete information for many past launches, NASA has employed best professional judgment in making assumptions regarding "expected" landing distances and azimuths to estimate the quantity and location of historic flight hardware in downrange lands. Regarding whether the absence of this information would be essential to making a reasoned choice among alternatives, it is not expected that it would be essential because it would be a historical baseline applicable to all alternatives considered in this EIS. While having complete information regarding the location of flight hardware would provide the best assessment of the cumulative effects of the program at PFRR, it is not expected to have a major bearing on NASA and or its cooperating agencies' abilities to select the most appropriate alternative for ultimate implementation.

4.15.6.3 *Actions Considered but not Evaluated in Detail*

Of the actions discussed in Sections 4.5.1 and 4.5.2, NASA eliminated a number of those not expected to measurably contribute to cumulative effects on key resource areas. **Table 4–37** below presents those actions eliminated from detailed evaluation of cumulative effects and NASA's reason for doing so.

Table 4–37. Projects Not Evaluated in Detail for Cumulative Effects

Action	Rationale for Not Evaluating in Detail
Long-Range Transportation Plan	No PFRR launches or recoveries expected within ROI of action
Polar Bear Conservation Plan	Negligible interaction between PFRR and action
Barter Island Airport Improvement	No PFRR launches or recoveries expected within ROI of action
Barter Island DEW-Line Cleanup	No PFRR launches or recoveries expected within ROI of action
Gold Mining at Livengood	No PFRR launches or recoveries expected within ROI of action
Dalton Highway Scenic Partnership Plan	No PFRR launches or recoveries expected within ROI of action
Foothills West Transportation	No PFRR launches or recoveries expected within ROI of action

Key: DEW=Distant Early Warning; PFRR=Poker Flat Research Range; ROI=region of influence.

4.15.6.4 *Resources Considered but not Evaluated in Detail*

In keeping with CEQ regulations **(40 CFR 1500–1508)**, those resource areas that were predicted to be impacted in at least a minor way were evaluated for their potential to contribute to cumulative effects within the cumulative effects ROI. Where impacts were predicted not to occur or were negligible, cumulative effects were generally not analyzed since there would be either no, or only a very small incremental increase in effects on the resource within the ROI.

No cumulative effects are anticipated for the following resource areas with respect to additional actions taking place within the PFRR launch site and launch corridor: geology and soils, subsistence resources, cultural resources, health and safety, and socioeconomics and environmental justice; thus, these resource areas are not discussed in the following sections.

4.15.7 Air Quality and Global Atmosphere

4.15.7.1 *Resource Context*

None of the areas within the PFRR launch corridor are designated as nonattainment areas with respect to the National Ambient Air Quality Standards for criteria air pollutants. Elevated concentrations of particulate matter occur near occupied areas during the winter partially as a result of wood-fired devices and throughout the launch corridor during summer as a result of wildfires.

The Earth's radiation balance is affected largely by water vapor; carbon dioxide; and other trace gases, including nitrous oxide, halocarbons, and methane. Increases in atmospheric concentrations of these pollutants are believed to influence the Earth's global climate **(IPCC 2007)**. The Arctic is especially vulnerable to global climate change and increased ultraviolet radiation. The primary impacts are expected physical and biological changes.

4.15.7.2 *Past and Present Impacts*

PFRR Actions

Past and current launches from PFRR have resulted in temporary air quality impacts from criteria pollutant and other air pollutant emissions from both sounding rocket flight and occasional recovery actions. These activities also produce greenhouse gases, which have global, negligible, and long-term adverse impacts.

Actions by Others

General Land Management **–** Landowner and resource agency aviation contributes to temporary impacts from production of criteria and other air pollutants throughout downrange lands. Long-term impacts from production of greenhouse gases also occur.

Recreational Use **–** The recreational use of all-terrain vehicles (ATVs) and outboard motors on downrange lands contributes to temporary impacts from production of criteria and other air pollutants throughout downrange lands during non-winter months, particularly on BLM lands where maintained trails are readily available for users. The use of snow machines during winter months also produces air pollutants. Long-term impacts from production of greenhouse gases also occur.

Interior Oil and Gas Exploration **–** Interior Oil and Gas exploration activities produce criteria and other air pollutants and greenhouse gases. The airborne transportation of equipment and personnel, mulching, borehole drilling, and the detonation of small explosive charges are sources of air pollutants.

4.15.7.3 *Future Impacts*

PFRR Actions

PFRR routine activities and rocket launches would result in minor, adverse, long- and short-term air quality impacts on a global level, as discussed in Section 4.2. Adverse impacts from search and recovery operations would be regional, minor, and medium-term. The adverse impact on the global atmosphere from emissions of greenhouse gases would be global, negligible, and long-term, as discussed in Section 4.2. When combined with the existing air quality impacts in the area near PFRR, little change in air pollutant concentrations is expected, and the air pollutant concentrations are expected to continue to be below ambient standards.

Actions by Others

***Interior Oil and Gas Exploration* –** Similar in nature to the impacts of past operations, future oil and gas exploration could result in air pollutant emissions from construction and exploration activities.

***Arctic Refuge Revised CCP* –** It is expected that all alternatives under consideration in the Draft Revised Arctic CCP would preserve minimal management of lands within Arctic NWR and air pollutant-producing activities would be kept to a minimum, thereby minimizing impacts on air quality.

***OCS Oil and Gas Leasing* –** Of the projects within the PFRR launch corridor, alternatives under the OCS Oil and Gas Leasing Program in the Beaufort Sea Planning Area could lead to air pollutant emissions from construction, exploration, and processing activities **(USDOI 2011b)**. These activities could result in fugitive dust emissions and other air pollutant emissions from drilling equipment, compressor stations, and other equipment. The impacts are not expected to result in significant adverse impacts on the communities within PFRR or the global atmosphere.

4.15.7.4 *Differences Among Alternatives Under Consideration*

Under Alternatives 1, 2, 3, and 4, there would be a minor change in air pollutant emissions from additional search and recovery operations in areas within the PFRR launch corridor.

Although annual emissions of greenhouse gases from launches at PFRR are negligible, when combined with those from other projects in the PFRR launch corridor, the effects would be additive and therefore would result in some contribution to climate change. However, scientific uncertainty limits the ability to assess directly attributable effects that directly contribute to climate change from selected individual actions. Therefore, NASA provides only a qualitative statement concerning these impacts. Cumulative effects from all alternatives under consideration would likely create impacts that increase climate change.

In general, climate change induced effects in the Arctic have led to earlier spring snowmelt, reduced sea ice, glacier retreat, and permafrost warming. Other effects of climate change in Alaska could include increased coastal erosion, flooding, shifts in marine species, drier conditions, increased wildfires, longer growing season, drought stress, and insect infestation of forests **(GCRP 2009)**.

4.15.8 Land Use and Recreation

4.15.8.1 *Resource Context*

Current land use patterns were largely set by ANILCA in 1980, which expanded Arctic NWR and established Yukon Flats NWR and the BLM-managed White Mountains NRA and Steese NCA. ANILCA also added Beaver Creek and the Ivishak, Sheenjek, and Wind Rivers to the National Wild and Scenic River System and the Mollie Beattie Wilderness Area of Arctic NWR to the National Wilderness Preservation System. With the exception of the area immediately surrounding villages, nearly all Federal lands within the PFRR launch corridor meet most Wilderness suitability criteria.

4.15.8.2 *Past and Present Impacts*

PFRR Actions

From the onset of operations at PFRR in the late 1960s, the Federal Government, the state of Alaska, and various tribal organizations have largely controlled downrange lands. As such, PFRR has historically maintained a series of agreements with downrange landowners to ensure that its operations do not conflict with land uses. The most notable of these agreements is likely that with the USDOI that was signed in 1969 to allow for the landing and recovery of flight hardware on DOI-managed lands, including what was at the time known as the Arctic Range (now Arctic NWR) **(Davis 2006)**.

Table 4–38 below presents a summary of probabilities of sounding rocket impact within designated and recommended Wilderness areas for the past 10 years; this timeframe was selected as it contains the most accurate dataset of planned impact locations for which probabilities of impact could be calculated. The probabilities indicate that the likelihood of impact from launches from the recent past was generally unlikely with the exception of several cases. Earlier launches, particularly those prior to ANILCA, could have had planned impact locations within these lands. The presence of historic impacts within a Wilderness area would detract from the wilderness characteristics of the area; however, the extent of the effect would be localized.

Table 4–38. Probability of Impact Within Wilderness over the Past 10 Years

Vehicle	Mission	Mollie Beattie Wilderness Area		Yukon NWR Recommended Wilderness	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant V	21128				
	21131			0.0	6,117
	21138	0.0	3,363,719		
	21139	2.5	40		
Orion	30044			0.1	1,569
	30047			0.1	1,010
	30049			0.1	778
	30050			0.1	768
	30051			0.0	12,786
	30052			0.4	252
	30058			0.2	405
	30059			0.2	401
	30073			0.2	545
Black Brant X	35034 & 037				
Black Brant IX	36200 & 206				
	36234	0.0	2,697,308		
	36242	44.2	2		
	36256 & 278				
	36257	0.0	6,649,820		
Black Brant XII	40014	0.3	350		
	40016	0.1	758		
	40017	2.4	42		
	40019	0.2	528		
	40020	0.3	399		
	40023	0.6	173		
	40025	0.4	245		

Table 4–38. Probability of Impact Within Wilderness over the Past 10 Years (*continued*)

Vehicle	Mission	Mollie Beattie Wilderness		Yukon NWR Recommended Wilderness	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Terrier-Improved Orion	41028	0.0	25,099		
	41029			0.0	28,986
	41034	0.0	8,986		
	41061				
	41062	0.0	168,350		
	41063	19.6	5		
	41064	0.0	29,103		
	41065	0.0	8,128		
	41076			0.0	8,333,333
	41077			0.0	1,559,673
	41078			0.0	17,403,108
	41079				
	41084			5.5	18

a. Blank cells indicate that calculated value was below reporting threshold of software.

Given the special designations that ANILCA established for the lands downrange from PFRR, over time the sensitivity to evidence of human presence within the lands, including PFRR-launched flight hardware, has increased, particularly for those recreational users hoping to have a wilderness experience. Based upon recent response to items located by downrange users visiting the downrange lands, reactions to locating PFRR-launched hardware have ranged from positive to negative and were highly dependent upon the individual. Those persons who reacted adversely to finding an item were concerned that its presence detracted from their ability to enjoy a wilderness experience.

According to data from USFWS, during the past 10 years, the number of permitted air operators in Arctic NWR has grown approximately 40 percent with the number of permitted recreational guiding businesses nearly doubling **(USFWS 2012)**. On BLM-managed lands, use has increased by approximately 5 percent each year and is expected to continue doing so **(USDOI 2012a)**. Given that visible evidence of past launches remains in downrange lands, and would likely be the case for years to come, the potential for a recreational user to encounter an item from a past launch is likely increasing. Coupled with a higher likelihood of encountering other users of downrange lands, effects of finding a piece of flight hardware on recreationalists desiring a wilderness experience could be exacerbated.

Actions by Others

***Interior Oil and Gas Exploration* –** Past effects on wilderness values of Federal lands are largely limited to the seismic survey lines that are still visible on the ground and from the air, and some limited placer mining on the BLM-managed White Mountains NRA. There is no evidence that the survey lines from past oil and gas exploration within Yukon Flats NWR are negatively affecting land use or recreation, though they may be facilitating access for trapping through the use of the cleared seismic survey lines **(USFWS 2010a)**.

4.15.8.3 *Future Impacts*

PFRR Actions

Future launches from PFRR would be expected to consist mostly of the longer-range class of rockets, requiring impact locations primarily in the ADNR North and South Special Use Areas, the southernmost portion of White Mountains NRA, and lands north of Yukon Flats NWR. In all cases, UAF would be required to obtain authorizations from the respective landowner(s) to ensure that impacts and recoveries are consistent with land uses. Based upon an assessment of the past 10 years of flight records, it would not be likely for items to land within the areas of greatest recreational uses, which in general terms are along Beaver Creek within White Mountains NRA and Yukon Flats NWR and several rivers north of the Brooks Range within Arctic NWR. Given that future recovery efforts would occur during non-winter months, it is possible that users of downrange lands could observe recovery aircraft as it transits between its home airport and the search or recovery site. Within the context of land use, NASA and PFRR would maintain an active search and recovery program and recovery aircraft would adhere to minimum flight elevation requirements as stipulated in landowner-issued authorizations. Regarding recreation, to some users, observing an aircraft could adversely affect his/her wilderness experience; however, to others it may have limited effect given that air transportation is very common in Interior Alaska. In either case, the impact would be short-term.

Given the success rate of locating newly launched stages and payloads from downrange lands, it is expected that some flight hardware would remain in downrange lands following each successive launch season. Therefore, similar to the discussion regarding the effects of past launches, localized long-term adverse cumulative effects on recreation, and in particular, wilderness-based recreation, would be anticipated should a sounding rocket-related item be encountered on downrange lands.

Actions by Others

BLM Eastern Interior RMP **–** Of the land areas under consideration in BLM’s revised RMP/EIS, the White Mountains subunit would have the greatest potential for overlap with PFRR’s activities. Under BLM’s preferred management alternative, identified as Alternative C in the Draft RMP/EIS, recreation management would be the focus in White Mountains NRA and surrounding lands, which would be identified as a Special Recreation Management Area. Under Alternative C, less land would be managed for Primitive and Semi-Primitive settings than other alternatives under consideration. A slight increase in site and facility development would occur. As such, it is expected that BLM’s future management of White Mountains NRA would result in beneficial impacts on recreation, particularly those activities that involve OHV use. Some displacement of non-motorized users could be expected **(USDOI 2012a)**. Based upon NASA’s discussions with BLM, it is not expected that land management changes under BLM’s preferred alternative would have a measurable effect on future launches of sounding rockets from PFRR.

Arctic Refuge Revised CCP **–** Once complete, the *Draft Revised Arctic CCP* will provide management direction for Arctic NWR for the next 15 years **(USFWS 2011c)**. USFWS is evaluating six alternatives in the *Draft Revised Arctic CCP*. These alternatives and their potential impact on land management within Arctic NWR and, by extension, portions of PFRR, are listed in **Table 4–39.**

Table 4–39. Alternatives Considered in the Arctic Refuge Draft Revised Comprehensive Conservation Plan

Alternative	Description	Wilderness
A	The original land management categories, as described in the 1988 Comprehensive Conservation Plan, would continue to apply to lands in Arctic NWR. Lands administered by Arctic NWR would fall into three management categories as follows: Minimal (4.3 million hectares), Wilderness (3.2 million hectares), and Wild River (202,000 hectares).	No new areas would be recommended for Wilderness designation.
B	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range WSA as Wilderness, there would be a reduction of 2.2 million hectares from the Minimal management category and a corresponding increase in the Wilderness management category. Similarly, if the recommended rivers were designated by Congress for inclusion in the NWSRS, there would be a further reduction of approximately 21,200 hectares of Minimal management and an increase of 21,100 hectares of Wild River management.	The Brooks Range WSA would be recommended for Wilderness designation.
C	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Coastal Plain WSA as Wilderness, there would be a reduction of 570,000 hectares from the Minimal management category and a corresponding increase in the Wilderness management category. Similarly, if Congress were to designate the rivers recommended for inclusion in the NWSRS, there would be a further reduction of approximately 2,800 hectares from the Minimal management category and an increase of 2,800 acres in the Wild River management category.	The Coastal Plain WSA would be recommended for Wilderness designation.

Table 4–39. Alternatives Considered in the Arctic Refuge Draft Revised Comprehensive Conservation Plan (*continued*)

Alternative	Description	Wilderness
D	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range and Porcupine Plateau WSAs as wilderness, there would be a reduction of 4 million hectares from the Minimal management category and a corresponding increase under the Wilderness management category. Similarly, if recommended rivers were designated by Congress for inclusion in the NWSRS, there would be a further reduction of approximately 22,000 hectares of Minimal management and an increase of 22,000 hectares of Wild River management.	The Brooks Range and Porcupine Plateau WSAs would be recommended for Wilderness designation.
E	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A. If Congress were to designate the Brooks Range, Porcupine Plateau, and Coastal Plain WSAs as Wilderness, there would be a reduction of 4.5 million hectares from the Minimal management category and a corresponding increase in the Wilderness management category. If rivers recommended under this alternative were designated as Wild Rivers by Congress, there would be a further reduction of 24,000 hectares from the Minimal management category and a corresponding increase in the Wild River management category.	The Brooks Range, Porcupine Plateau, and Coastal Plain WSAs would be recommended for Wilderness designation.
F	Lands in Arctic NWR would be managed under the Minimal, Wilderness, and Wild River management categories described in the *Draft Revised Arctic CCP*. This alternative would maintain the same area in each of the management categories as Alternative A.	No new areas would be recommended for Wilderness designation.

Note: To convert hectares to acres, multiply by 2.471.
Key: *Draft Revised Arctic CCP=Arctic Refuge Draft Revised Comprehensive Conservation Plan*; NWR=National Wildlife Refuge; NWSRS=National Wild and Scenic River System; WSA=Wilderness Study Area.
Source: USFWS 2011c.

The alternatives considering managing areas as Wilderness areas and Wild River segments, as shown in Table 4–39, could limit activities that could occur within Arctic NWR, decrease the area within Arctic NWR in which UAF and NASA would be able to launch and recover sounding rockets, and limit the potential impacts of such launches on land use and recreation within Arctic NWR. Given this potential conflict, NASA has joined the USFWS project team as a formal cooperating agency and has provided information for the *Final CCP/EIS* regarding the potential effects of each alternative on its sounding rockets operations at PFRR.

It is not anticipated that implementation of Alternative A would have an effect on the continued launch of sounding rockets from PFRR. NASA would continue to conduct its missions such that there are no planned impacts within Mollie Beattie Wilderness Area, and through the UAF, would secure permission for landing and recovery of rocket hardware within the remaining areas of Arctic NWR on an as-needed basis.

Implementation of Alternative B would have a major adverse effect on NASA's ability to launch sounding rockets from PFRR. As shown below in **Figure 4–21**, the most commonly flown sounding rocket configurations within the past 10 years have been the BB-class and T-IOs, the trajectories of which would likely have a planned impact within the Brooks Range Wilderness Study Area (WSA). Therefore, assuming a launch rate of four rockets per year, the designation of the Brooks Range WSA as Wilderness could eliminate NASA's ability to fly an expected 28 of the 30 Arctic NWR landing missions within the 15-year planning horizon of the CCP.

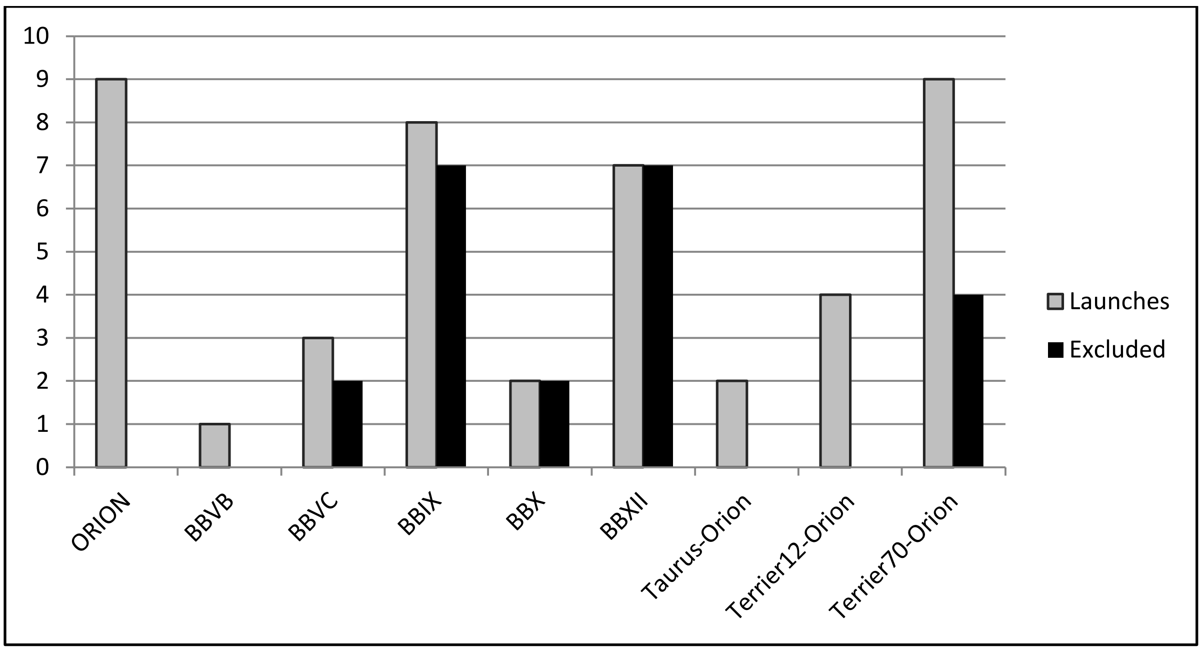


Figure 4–21. Sounding Rockets Launched from PFRR Within Last 10 Years and Those That Would Have Been Excluded by Designation of Brooks Range WSA

Considering that at least half of its future missions at PFRR would be excluded by implementation of this alternative, it is likely that NASA would discontinue funding PFRR's operations and maintenance altogether.

It is not expected that implementation of Alternative C would have an adverse impact on the continued launch of sounding rockets from PFRR. In general, planned impact locations within Arctic NWR are not further north of the Ivishak River; water landings in the Beaufort Sea/Arctic Ocean are generally not closer than 350 kilometers (220 miles) north of Barter Island.

As designation of the Coastal Plain WSA would likely restrict the future installation of certain infrastructure and the onset of commercial activities within the area, it could benefit SRP. The future year-round presence of high-value infrastructure and additional people within the PFRR launch corridor could place further restrictions on allowable missions due to mandatory flight safety considerations. Implementation of Alternative C could alleviate this possibility.

Alternative D's impacts on the NASA SRP would be similar in type but likely greater in magnitude to those discussed under Alternative B. Although there have been no planned impacts within the Porcupine Plateau WSA within the past 10 years of PFRR launches, the potential cannot be discounted. Therefore, it is possible that a currently unquantified number of moderate-range launches could be eliminated in addition to those affected by designation of the Brooks Range WSA. Accordingly, of all the alternatives under consideration, this alternative would likely have the greatest adverse effects on SRP.

Impacts on the NASA SRP from Alternative E would be the same as under Alternative D. It is not expected that the additional designation of the Coastal Plain WSA provided under this alternative would have a measurable positive effect on the program given that all rocket configurations having the capability to either overfly or land within the vicinity of the Coastal Plain (*e.g.*, BB X and XII) would also require authorization for spent rocket motors to impact within one of the lower-latitude WSAs, thereby precluding their flight.

OCS Oil and Gas Leasing – According to the *OCS Oil and Gas Draft PEIS* **(USDOI 2011b)** impacts on land use within the Beaufort Sea Planning Area would be minor to moderate from the development of new oil and gas leases within Beaufort Sea. Existing land use and infrastructure likely would be able to accommodate new leases. In general, land use changes would be needed only in locations where new onshore pipeline routes would be constructed, and in areas requiring new transportation networks. No cumulative effects from implementation of the *PFRR EIS* alternatives and the alternatives evaluated in the *OCS Oil and Gas Draft PEIS* are anticipated. No additional cumulative effects on land use are anticipated when combined with the potential impacts of the other actions in the cumulative effects ROI beyond those associated with the *Draft Revised Arctic CCP*.

4.15.8.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would contribute the most to long-term adverse cumulative effects on land use and recreation because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, and current requirements of downrange landowners to recover items, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major cumulative effects on these resource areas. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternatives 3 and 5, which would extend the restriction on planned impacts on designated Wild Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects.

4.15.9 Visual Resources

4.15.9.1 *Resource Context*

The lands within the PFRR launch corridor are largely undeveloped and pristine, showing little sign of human activity except in villages.

4.15.9.2 *Past and Present Impacts*

PFRR Actions

The launching of sounding rockets from PFRR since 1969 has led to the impacting of rocket motors, payloads, and ancillary items within the PFRR launch corridor. Given the limited focus on search and recovery of these items in the past, much remains in downrange lands (see Section 4.12, Waste Management). For some users of the downrange lands, particularly those desiring a wilderness experience, encountering an item launched from PFRR could be considered an adverse impact on visual resources. However, to others, it could be viewed as a positive experience. In either case, the extent of the effect would be localized and confined to a small area immediately at and adjacent to the impact site.

Actions by Others

Past activities related to resource exploration, public use, and military operations have resulted in visible signs of human activity in areas that are otherwise in a natural condition. For example, scattered across downrange lands is an unquantified amount of debris (*e.g.,* drums, aircraft remains) from past activities. Additionally, a 1950s bulldozer trail parallels a section of the Coleen River within Arctic NWR. It is recovering and becoming less apparent from the ground; however, two abandoned tractor-trailers and other heavy debris are found along the trail. Along the coast, structures at the former Camden Bay, Beaufort Lagoon, and Demarcation Point DEW-Line sites have been removed, but gravel pads and some concrete foundations remain **(USFWS 2012)**.

General Land Management – The construction of support infrastructure in downrange lands has modified the landscape, however at a negligible scale when considered within the geographic extent of the cumulative effects analysis area. Yukon Flats NWR maintains three small radio repeater sites and one cabin at Canvasback Lake. Additionally, approximately 12 seasonal weather stations are deployed by the Alaska Fire Service on Yukon Flats NWR lands during the summer months. Several cabins have been constructed within Arctic NWR in the Old John Lake area and several other Native allotments. USFWS maintains two cabins on Big Ram Lake.

Recreational Use – In White Mountains NRA, summer ATV travel has historically occurred within White Mountains NRA with many trails visible for long distances from elevated locations **(USDOI 2012a)**.

Historic Placer Mining – Although some placer mining has been conducted in the past, particularly in the Nome Creek area, White Mountains NRA remains largely pristine, with no noticeable cumulative effects due to past or present activities.

Interior Oil and Gas Exploration **–** Other evidence of past effects on visual resources within the Yukon Flats Basin is associated with the cleared survey lines from past (1970 to 2001) seismic surveys. Approximately 175 hectares (430 acres) have been cleared along 286 kilometers (178 miles) of survey lines. The lines are still visible from the ground and air and portions of two of these seismic lines are within the recommended-Wilderness area in Yukon Flats NWR **(USFWS 2010a)**. Scattered sections of seismic trails from the 1984–1985 oil and gas exploration in Arctic NWR are visible, mostly from the air **(USFWS 2012)**.

Summary

The presence of visible signs of human activity within downrange lands would result in an adverse impact on the lands' otherwise natural visual resources; however, the extent of the impacts is localized when considered within the vast geographic area that composes the PFRR launch corridor. The duration of most past impacts are generally long-term, either in the form of a disturbance (such as the trail) which would require years of successional growth for the site to regain its natural character, or in the form of a semi-permanent facility such as a structure.

4.15.9.3 *Future Impacts*

PFRR Actions

With the recent focus on recovery of flight hardware from the lands within the PFRR flight corridor, it is possible that users of downrange lands could see a search or recovery aircraft, which to some would be considered an adverse impact. The sensitivity to witnessing a recovery-related helicopter flight would likely be greatest in Arctic NWR, where helicopter landings are infrequent. However, the duration of the sighting would be short-term. The geographic extent from which the aircraft or ground crew could be seen would be highly variable and a function of the elevation and ground cover at both the recovery site and the vantage point of the observer. Based upon an assessment of the past 10 years of flight records, it would not be likely for items to land within the areas of greatest recreational uses (see Section 4.8), which would limit the potential for interaction.

Given the approximately 50 percent success rate of locating newly launched stages and payloads from downrange lands, it is expected that some flight hardware would remain in downrange lands following each successive launch season. Therefore, similar to the discussion regarding the effects of past launches, long-term adverse cumulative effects on visual resources would be anticipated; however, the geographic extent of the impact would be local.

Actions by Others

BLM Eastern Interior RMP **–** Under BLM's preferred alternative, approximately 33 percent of White Mountains NRA would be managed as VRM Classes I and II, which would be expected to provide continuing long-term benefits to visual resources.

Interior Oil and Gas Exploration **–** Visual resources would be affected by the clearing of vegetation for seismic survey lines and access trails, or for ice pads for exploratory drilling. These clearings would be visible from the air and from the ground and would contrast markedly from the surrounding lands in forested areas, thereby adversely affecting visual resources. The effects would be additive due to the length of time required for regrowth of the vegetation, which can be multiple decades in forested areas. The clearings would be spread over several hundred thousand acres in the Arctic NWR and would be visible for several miles from the air. These effects would be masked in areas burned by wildland fires before or after the surveys.

4.15.9.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would contribute the most to long-term adverse cumulative effects on visual resources because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major effects on these resource areas. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternatives 3 and 5, which would extend the restriction on planned impacts on designated Wild and Scenic Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects.

4.15.10 Water Resources

4.15.10.1 *Resource Context*

Though water quality data are generally limited for the vast number of wetlands, lakes, rivers, and streams within the PFRR launch corridor, it is generally accepted that water quality is good **(USDOI 2012a; USFWS 2012)**. Designated Wild Rivers within the PFRR launch corridor (from south to north) are Beaver Creek within White Mountains NRA and Yukon Flats NWR, and the Sheenjek, Wind, and Ivishak Rivers within Arctic NWR.

4.15.10.2 *Past and Present Impacts*

PFRR Actions

Historic launches from PFRR have likely landed within downrange water resources, likely resulting in localized degradation of water quality immediately adjacent to the impact site. Stages or payloads that have landed within designated Wild River corridors could also detract from the natural, undisturbed setting of the area; however, the extent of the impact would be localized. Recent reports from recreational users of downrange lands, notably Arctic NWR, have reported spent rocket stages within the Wind River corridor; however, those items were removed by PFRR during summer 2011. **Table 4–40** presents the calculated probabilities of impact within each respective Wild River for the past 10 years of launches; this timeframe was selected as it contains the most accurate dataset of planned impact locations for which probabilities of impact could be calculated.

Table 4–40. Probability of Impact Within Wild River Corridors over the Past 10 Years

Vehicle	Mission	Ivishak River		Wind River		Sheenjek River		Beaver Creek	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant V	21128			0.3	301	0.0	11,272		
	21131			0.0	953,380			0.0	1,990,565
	21138	0.0	8,151	6.4	16	0.0	382,146		
	21139			0.0	27,997	0.2	446		
Orion	30044							7.9	13
	30047							10.2	10
	30049							6.5	15
	30050							6.5	15
	30051							3.7	27
	30052							7.9	13
	30058							7.9	13
	30059							7.9	13
	30073							12.0	8
Black Brant X	35034			0.7	141				
	35037			1.0	105				
Black Brant IX	36200	0.0	1,907,378	1.1	92	0.0	357,654		
	36206			0.4	236	0.0	31,319		
	36234			7.5	13				
	36242	0.3	335	0.1	672	2.5	41		
	36256	0.0	40,304,704	0.7	139	0.0	3,399,279		
	36257	0.0	81,064	2.0	50	0.0	142,584		
	36278	0.0	32,634,945	0.7	152	0.0	3,440,328		

Table 4–40. Probability of Impact Within Wild River Corridors over the Past 10 Years (*continued*)

Vehicle	Mission	Ivishak River		Wind River		Sheenjek River		Beaver Creek	
		Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)	Probability[a] (percent)	Probability[a] (1:)
Black Brant XII	40014	9.2	11	7.1	14	0.0	560,884		
	40016	2.8	36	6.8	15	0.0	457,917		
	40017	5.3	19	3.6	28	0.0	29,526		
	40019	3.1	33	6.5	15	0.0	254,634		
	40020	4.0	25	5.9	17	0.0	479,823		
	40023	3.2	32	4.8	21	0.0	40,414		
	40025	2.3	43	5.0	20	0.0	46,098		
Terrier-Improved Orion	41028	0.0	4,528,370	1.3	75	0.2	565		
	41029			0.0	3,394,548				
	41034	0.0	1,588,487	1.6	62	0.2	466		
	41061	0.0	7,122,000	0.2	502				
	41062	16.3	6	29.8	3				
	41063	0.0	222,010	0.0	6,350	1.7	58		
	41064	0.4	249	10.6	9	0.0	91,676		
	41065	0.6	167	10.2	10	0.0	31,589		
	41076-41084								

a. Blank cells indicate that calculated value was below reporting threshold of software.

Actions by Others

Minor cumulative effects on water resources have occurred over time from activities within the PFRR launch corridor. These include effects on water movement and quality from the construction of roads, airstrips, building pads, and other infrastructure associated with villages, and from untreated sewage **(USFWS 2010a)**.

Recreational Use **–** Cross-country summer use of OHVs can occur on up to 61 percent of the White Mountains NRA and has the potential to contribute to adverse impacts on water quality **(USDOI 2012a)**. ATVs can disturb sediments, leading to sediment-laden runoff during storm events. During non-winter months, the use of snowmobiles on downrange lands can result in the deposition of petroleum products, particularly within and immediately adjacent to well-used trails.

Historic Placer Mining – Historical placer mining in Nome Creek, a tributary to Beaver Creek Wild River, resulted in the destruction of approximately 11 kilometers (7 miles) of the stream channel, floodplain, and riparian areas. Additionally, the exposed mine tailings cause excessive sediment transport and are the principal source of sediment carried to Beaver Creek. In 1991, BLM initiated a program to reclaim the headwaters of Nome Creek and restore its associated riparian habitat. To date, a total of over 6 miles of Nome Creek have been reconstructed and stabilized and over 120 hectares (300 acres) of floodplain have been created during the project.

4.15.10.3 *Future Impacts*

PFRR Actions

The future probabilities of sounding rocket flight hardware landing within Wild and Scenic River corridors would likely be similar to those shown for the past 10 years in **Table 4–41**. The vehicle with the greatest likelihood of landing within Beaver Creek would be the single-stage Orion, the launch of which is possible; however, it is expected to be infrequent due to the consistent specification of longer-range rockets by PFRR-supported researchers. Impacts on the Sheenjek River from most launches would be negligible; however, it is possible that several missions could have a minor probability of impact if the scientific objectives dictated a flight along a more northeasterly trajectory. Potential impacts within the Wind and Ivishak Rivers would be highly variable with the moderate range two-stage rockets (*e.g.*, T-IO, BB IX), as evidenced by the probabilities from the past 10 years. Given the mandatory safety buffers from the Trans-Alaska Pipeline on the west and Arctic Village to the east, launching the BB XII would be expected to present similar probabilities of impact on both rivers, generally ranging from 2 to 10 percent.

Table 4–41. Wild Rivers Being Considered by the Arctic National Wildlife Refuge

Alternative	Wild Rivers
A	No new rivers would be recommended for Wild River designation. Arctic NWR would use existing management tools to maintain values on the Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers.
B	The Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers. Arctic NWR would use existing management tools to maintain values for the Atigun River.
C	The Atigun River would be recommended for inclusion in NWSRS as a Wild River. Arctic NWR would use existing management tools to maintain values for the Hulahula, Kongakut, and Marsh Fork Canning Rivers.
D	The Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers. Only those portions of the Hulahula River managed by Arctic NWR would be included in the recommendation.
E	The Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers would be recommended for inclusion in NWSRS as Wild Rivers.
F	No new rivers would be recommended for Wild River designation. Arctic NWR would use existing management tools to maintain values on the Atigun, Hulahula, Kongakut, and Marsh Fork Canning Rivers.

Key: NWR=National Wildlife Refuge; NWSRS=National Wild and Scenic River System.
Source: USFWS 2011c.

Actions by Others

BLM Eastern Interior RMP **–** Although Alternative B in the *Draft RMP/EIS* would recommend Fossil Creek as "scenic," it is not BLM's preferred alternative, and will not be further considered in this section.

As BLM's preferred alternative would entail an increased development of visitor facilities within White Mountains NRA, minor adverse impacts on water quality could result during land-disturbing construction activities. However, it is expected that seasonal travel restrictions on OHVs would reduce the level of impact on water resources that is currently occurring. It is also expected that the effects of user-made trails would be substantially reduced **(USDOI 2012a)**.

Interior Oil and Gas Exploration **–** Cumulative effects on water resources from oil and gas exploration could include disturbances to soil, water, and vegetation from seismic surveys, which could lead to increased erosion and sedimentation in rivers and lakes; removal of water from lakes for ice pads and drilling; and small leaks or spills of fuels or lubricants during the use of petroleum-powered equipment. Such effects would be minimized by requirements to conduct such work during winter months when the ground and surface waters are frozen. Although there are no such requirements for work conducted on private lands, many of the downrange lands within the PFRR launch corridor are owned by either the Federal or state government, both of which have established protocols to minimized environmental impacts. For example, on state lands on Alaska's North Slope, ADNR requires that there be 15 centimeters (6 inches) of frost and 15 centimeters (6 inches) of snow before overland tundra travel can occur. On other State of Alaska lands in the interior, permits issued by ADNR for exploration stipulate that there must sufficient depth of snow and ice to protect the ground surface.

Arctic Refuge Revised CCP **–** Alternatives evaluated in the *Draft Revised Arctic CCP* **(USFWS 2011c)** could affect Wild River segments within the PFRR launch corridor (see Chapter 3, Section 3.3.2). Proposed changes being considered by Arctic NWR are presented in Table 4–44. Should these rivers be managed as Wild Rivers, it could limit some launch trajectories (as proposed for Alternatives 3 and 4 of this *PFRR EIS*) for future launches from PFRR. In particular, the designation of river segments outside of Mollie Beattie Wilderness Area (*e.g.,* Atigun and Marsh Fork) could result in potential use conflicts similar to those discussed in Section 4.15.5. However, given the proximity of the Atigun River to the Trans-Alaska Pipeline and in consideration of mandatory range safety requirements, it is not expected that a planned impact point would be located in its vicinity. In relative terms, the Marsh Fork of the Canning River would have a higher likelihood of a sounding rocket stage or payload landing within it; however, given its smaller size and the dispersion of rockets that would be expected to land within that area, the probabilities would be lower than those calculated for the nearby Wind and Ivishak Rivers. Designation of the other proposed rivers (*i.e.,* Hulahula, Kongakut) would not have a measurable impact on the NASA SRP as they are within an area that is already avoided during mission planning (*i.e.,* Mollie Beattie Wilderness Area).

OCS Oil and Gas Leasing **–** The proposed OCS Oil and Gas Leasing Program provides a schedule for offshore oil and gas exploration and development lease sales spanning from 2012 to 2017. For the program period, one sale is scheduled for 2015 in the Beaufort Sea **(USDOI 2011c)**. The OCS *Oil and Gas Draft PEIS* **(USDOI 2011b)** found that routine lease exploration and development activities near construction sites within the Beaufort Sea would result in minor to moderate, short-term, localized water quality impacts (sedimentation and increased turbidity) primarily from operational discharges. Should offshore oil and gas exploration begin in areas of the Beaufort Sea within the PFRR launch corridor, it could possibly limit future launch trajectories from PFRR.

4.15.10.4 *Differences Among Alternatives Under Consideration*

It is expected that all five alternatives would contribute similarly to cumulative effects on water resources. In relative terms, it is likely that the No Action Alternative would have the greatest potential effects due to the infrequent recovery actions that it would entail; therefore, the greatest quantities of wastes would remain in downrange lands, which could result in a localized reduction in water quality at aqueous impact sites. Alternative 1 would have fewer adverse effects as stages and payloads would be removed when deemed environmentally responsible. Alternative 2 would have fewer long-term cumulative effects, as more items would be removed from downrange lands. Short-term impacts (*e.g.,* turbidity from recovery) could be greater than Alternative 1 due to more intense recovery efforts; however, in either case impacts would be expected to be negligible due to the limited extent of an impact site. Alternatives 3 and 4 would likely have the least additive effects on water resources, as they would require restricted trajectories such that no planned impacts would occur within designated Wild and Scenic River corridors.

4.15.11 Ecological Resources

4.15.11.1 *Resource Context*

The PFRR launch corridor is home to a diverse array of plants, fish, and resident and migratory wildlife species. Wildlife abundance is highest during non-winter months.

4.15.11.2 *Past and Present Impacts*

PFRR Actions

Ground-disturbing activities (and resulting effects on vegetation) associated with past operations have been minimal due to the limited focus on recovery of stages and payloads. Likewise, noise and visual disturbances to wildlife from aircraft overflights have been minimal.

Actions by Others

Interior Oil and Gas Exploration – In the Yukon Flats Basin, past seismic surveys have resulted in clearing of vegetation on about 175 hectares (430 acres) along 286 kilometers (178 miles) of survey lines. These lines are still visible, and may be having some effect on the habitat value to wildlife. Researchers have reported that boreal birds appear resistant to the edge/habitat fragmentation effects associated with forest clearing, and studies in boreal forests have found no effects on bird populations or bird densities from seismic lines **(USFWS 2010a)**. Moreover, the small size of the disturbance in relation to the amount of available habitat for all species leads to the conclusion that adverse cumulative effects, while long term, would be minor.

4.15.11.3 *Future Impacts*

PFRR Actions

Continuation of sounding rocket launches at PFRR would result in negligible adverse impacts on vegetation from either crushing or clearing during recovery activities; the extent of the impact would be limited to the area immediately adjacent to the impact site. It is expected that successional processes would result in the re-establishment of ground cover shortly thereafter.

Short-term noise and visual disturbances on wildlife would be expected primarily from search and recovery activities; however, impacts would be limited in extent.

Actions by Others

BLM Eastern Interior RMP – BLM's preferred alternative in its *Draft RMP/EIS* would permit a slight increase in the area in which summer OHVs would be allowed within White Mountains NRA; however, all would be required to operate on designated trails, which would considerably reduce adverse effects on both vegetation and wildlife. Primitive camping would be allowed within designated Research Natural Areas (RNAs), which could result in greater disturbance of wildlife species in those areas; however, effects would be minor. During winter months, a provision to monitor snowmobile use within non-forested caribou habitat and adjust management as needed would benefit the species **(USDOI 2012a)**.

Interior Oil and Gas Exploration **–** Adverse cumulative effects on vegetation would be expected due to the clearing necessary to perform seismic surveys or establish exploratory wells. The time required to re-establish pre-existing cover would depend upon the vegetative community, and could take multiple decades in the case of forested areas. A complicating factor in estimating the required timeframe for recovery is the frequency of wildfires in the Yukon Flats, which could possibly interrupt or reset the process of succession **(USFWS 2010a)**. Direct impacts on migratory birds would also be minimized because most activities would be expected to occur during late winter outside of the prime migration window of most species. However, raptors migrate to the Yukon Flats in mid- to late-April and waterfowl species, such as mallard and northern pintail, arrive in late April **(USFWS 2010a)**. Short-term, localized disturbance may occur to wildlife (*e.g.,* wolf, moose) in the area of the activities. For example, wildlife may scatter and be displaced during detonation of explosives or when helicopters are low to the ground. However, any displacement would likely be short-term and on a localized scale.

Arctic Refuge Revised CCP **–** The alternatives presented in the *Draft Revised Arctic CCP* consider the designation of additional areas within Arctic NWR to be managed as Wilderness, Wild and Scenic Rivers, and minimal management areas **(USFWS 2011c)**. These changes in land use designation and management are expected to have beneficial or neutral effects on biological resources.

OCS Oil and Gas Leasing **–** The potential leasing of the waters offshore of Kaktovik for oil and gas exploration would occur in the same general area where BB XII payloads and final spent stages could land. The effects of the PFRR activities would be negligible in comparison to the considerable human, boat, aircraft, seismic exploration, and exploratory drilling activities, as well as the potential spills or other environmental contamination that could be associated with the OCS oil and gas exploration in the region and would not contribute appreciably to cumulative effects.

4.15.11.4 *Differences Among Alternatives Under Consideration*

In relative terms, Alternative 2 and 4 would likely contribute the most to potential cumulative effects on ecological resources where they would entail the greatest recovery effort. Their implementation could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. Alternative 1 would contribute fewer effects as it would enable certain items to be left in place if an attempted recovery would be more intrusive than leaving the item in place. Alternative 3, which would extend the restriction on planned impacts to designated Wild Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects. The No Action Alternative would contribute the least to adverse cumulative short-term disturbance due to its very limited search and recovery effort.

In summary, potential adverse impacts on ecological resources from either alternative would be infrequent and negligible in extent when compared to other actions considered in the cumulative effects analysis. Therefore, the project would not contribute appreciably to cumulative effects of other projects in the region.

4.15.12 Waste

4.15.12.1 *Past and Present Impacts*

PFRR Actions

Spent Stages and Payloads – Currently, there are no non-NASA launches occurring at PFRR, nor are any planned for the future. However, 116 non-NASA launches occurred from 1969 to 1995 **(UAF 2011c)**. These launches deposited approximately 64,000 kilograms (141,000 pounds) of material into the launch corridor. Thirty-four payloads were retrieved, resulting in the removal of approximately 9,900 kilograms (22,000 pounds) of material. Therefore, approximately 55,000 kilograms (121,000 pounds) remain in the launch corridor.

As discussed in Section 4.12, approximately 126,000 kilograms (278,000 pounds) of spent stages and payloads are estimated to remain in the launch corridor from past NASA launches with the majority of this material located within the special use areas designated by ADNR. Therefore, a combined total of approximately 181,000 kilograms (399,000 pounds) of payloads and spent stages remain in the launch corridor from past NASA and non-NASA launches. **Table 4–42** presents a summary of the PFRR-launched items estimated to remain in downrange lands.

Table 4–42. Summary of Flight Hardware Estimated to Remain in Downrange Lands

Distance (km)	Location[a]	NASA		Non-NASA		Total		Percent of Total	
		Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]
0–12	State of Alaska - PFRR Special Use	202	0	93	1	295	1	44%	<1%
12–80	BLM - White Mountains NRA	50	23	31	23	81	46	12%	18%
80–250	USFWS - Yukon Flats NWR	46	33	34	18	80	51	12%	20%
250–550	USFWS - Arctic NWR[d]	76–89	46–54	4	2	80–93	48–56	12–14%	19–22%
250–350	Native Village of Venetie[d]	19–25	12–15	1	1	20–26	13–16	3–4%	5–6%
250–350	State of Alaska[d]	19–25	12–15	1	1	20–26	13–16	3–4%	5–6%

Table 4–42. Summary of Flight Hardware Estimated to Remain in Downrange Lands (*continued*)

Distance (km)	Location[a]	NASA		Non-NASA		Total		Percent of Total	
		Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]	Spent Stages[b]	Payloads[c]
Over 550	Beaufort Sea/Arctic Ocean	34	34	0	0	34	34	5%	14%
Unknown[e]		2	1	43	35	45	36	7%	14%
Total		**461**	**168**	**207**	**81**	**589[b]**	**249**		

a. While possible that flight hardware may be located on other private or Village lands, it is expected that the majority of items are within the lands shown in this table.

b. Only the final Total figure reflects those spent stages recovered in the past (n=77) as specific detail regarding land parcel or sponsoring agency (*i.e.,* NASA versus Non-NASA) is not available; the figures presented for each land parcel should therefore be considered a maximum case.

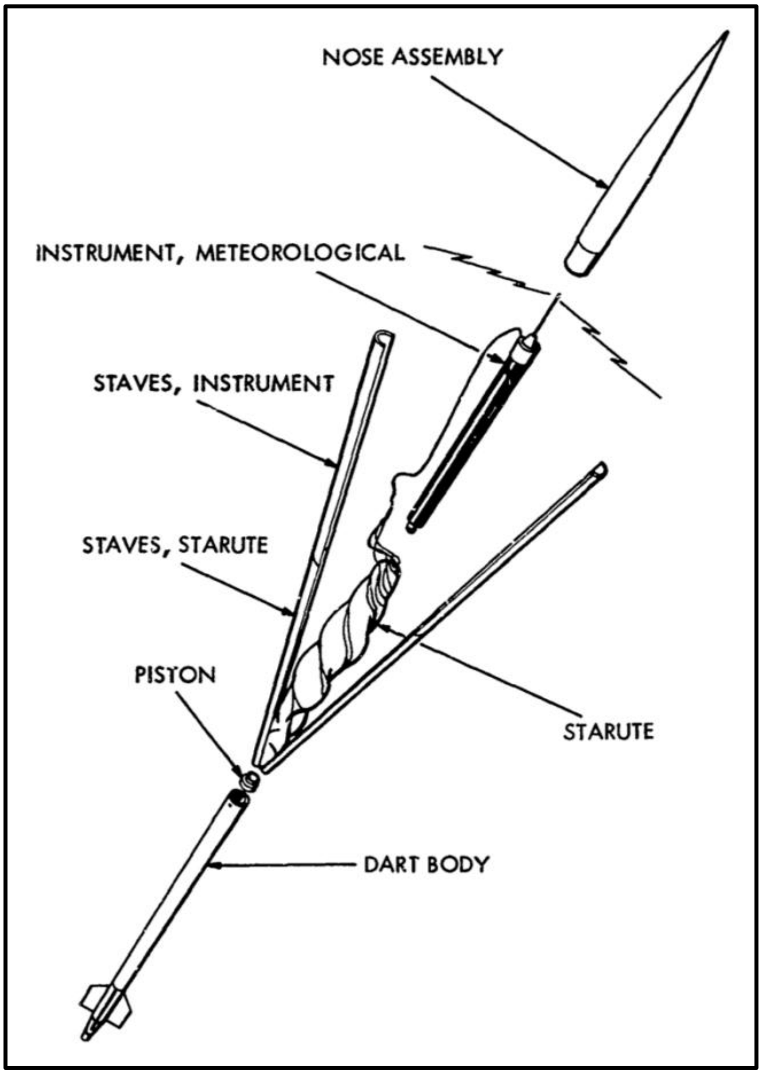
c. Figures presented account for payloads known to have been recovered (NASA 50; non-NASA 35).

d. Assumes between 60 and 70 percent of stages at this distance are within Arctic NWR, with remaining items split equally.

e. Indicates that neither mission-specific nor general vehicle performance data were available.

Key: km=kilometers; PFRR=Poker Flat Research Range; BLM=U.S. Bureau of Land Management; NWR=National Wildlife Refuge; NRA=National Recreation Area; USFWS=U.S. Fish and Wildlife Service.

***Meteorological Rockets* –** The U.S. Army's meteorological rocket program at PFRR launched an estimated 1,400 Super Loki Darts during its 9-year tenure (see **Figure 4–22**). The rocket motor for these vehicles consisted of a 2-meter-long (6.5-feet-long), 10-centimeter-diamter (4-inch-diameter) aluminum casing filed with solid propellant. The 1.3-meter-long (4.3-feet-long), 5 centimeter-diameter (2 inch-diameter) steel non-propulsive second stage contained a small (about 1 pound) parachuted transponder payload which upon release provided data to a ground station. Power for the instrument was provided by an 8-ounce nickel cadmium battery pack. Nearly all launches were along an easterly trajectory. **Table 4–43** provides a summary of the material that is estimated to remain in downrange lands.



Source: Bollerman *et al.* 1972.

Figure 4–22. Meteorological Rocket Flown from PFRR in the 1970s (does not show booster)

Table 4–43. Meteorological Rocket Hardware Estimated to Remain in Downrange Lands

Item	Weight Each (kilograms)	Items Launched	Cumulative Weight (kilograms)	Downrange Distance (kilometers)	Landowner
Expended Booster	6	1,400	8,400	0.5	State of Alaska
Instrumented Dart	8	1,400	11,200	45–55	State of Alaska

Launch Support Items – In the early years of PFRR's operations, and specifically regarding non-NASA launches, mid- and upper-level meteorological balloons carrying a small piece of aluminum foil "chaff" were used (see **Figure 4–23**). For the NASA launches, it was assumed that the bulk of balloons were carrying "chaff" with the exception of a middle and upper-level balloon that carried a foil-covered polystyrene foil target (see **Figure 4–24**) during each night of countdown. It has only been within approximately the last five launch seasons that the GPS radiosonde instruments have been flown on the mid- and upper-level balloons. The small folding fin test rockets, which are used to calibrate radar systems prior to launch, have historically been flown at a frequency of 1–2 per night counting.

Figure 4–23. Typical Aluminum Foil "Chaff" Historically and Currently Flown During Countdown

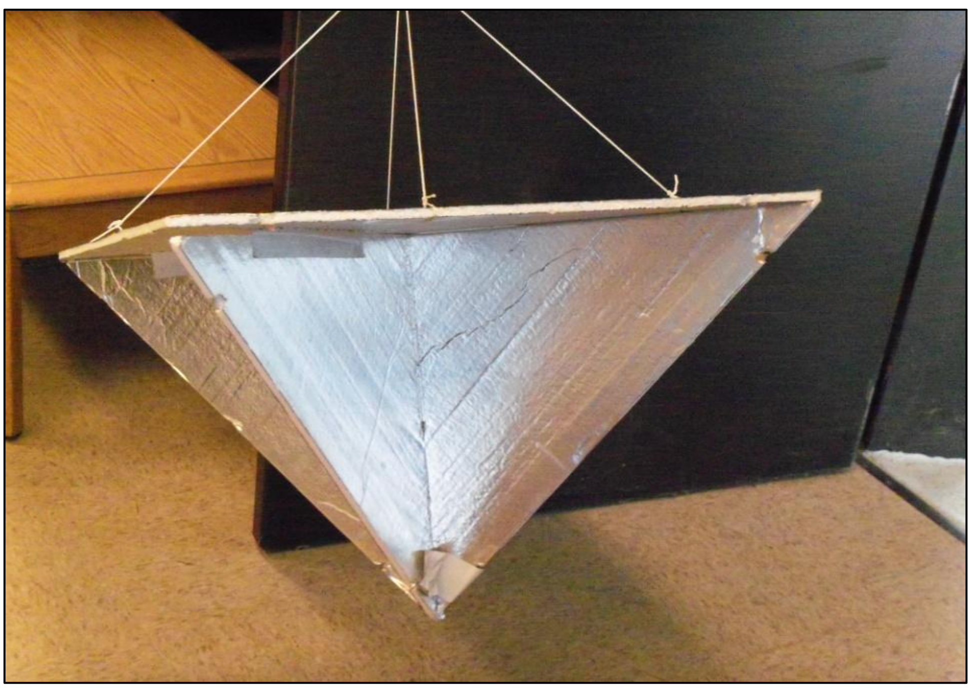


Figure 4–24. Radar Target Historically Flown During Countdown

As latex is a biodegradable material, it is assumed that all latex items older than 2 years have already degraded. The polystyrene items and test rockets, which would not be expected to undergo any measurable form of degradation, are assumed to remain in downrange lands. **Table 4–44** below provides a summary estimate of launch support items flown from PFRR since its inception and the weight of those items expected to remain in downrange lands.

Table 4–44. Past Launch Support Items and Estimated Weights in Downrange Lands

Item	Weight Each (kg)	Items Per Launch[a]	Launches Supported[b]	Cumulative Weight (kg)	Downrange Distance (km)	Landowner
NASA Launches						
"Chaff" Latex Balloon	0.1	120	172	2,064	50–80	State of AK or BLM
Mid-Altitude Latex Balloon	0.3	10	172	516	80–100	State of AK, BLM, or USFWS YFNWR
High-Altitude Latex Balloon	1.2	10	172	2,064	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	0.25	20	14	70	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Foil-Covered Polystyrene Radar Target	0.225	20	158	711	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	172	17,544	4–5	State of AK
Mid-Altitude Latex Balloon with Foil	0.3	180	116	6,264	80–100	State of AK, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon with Foil	1.2	20	116	2,784	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	116	11,832	4–5	State of AK

Table 4–44. Past Launch Support Items and Estimated Weights in Downrange Lands (*continued*)

Item	Weight Each (kg)	Items Per Launch[a]	Launches Supported[b]	Cumulative Weight (kg)	Downrange Distance (km)	Landowner
Summary (kg)						
Latex Balloons Launched	–	–	–	13,692		
Less Latex Degradation	–	–	–	(13,557)		
Remaining Latex	–	–	–	135	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	–	–	–	781	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rockets	–	–	–	29,376	4–5	State of AK

a. Each launch requires 10 days of countdown with a 6-hour launch window.
b. When multiple launches occurred on the same day (n=44), data collected by launch support items are "shared" among all launches.

Notes: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.
Key: AK=Alaska; BLM=U.S. Bureau of Land Management; kg=kilograms; km=kilometers; NWR=National Wildlife Refuge; USFWS=U.S. Fish and Wildlife Service.

Actions by Others

Past activities related to public use, military operations, and other agencies and institutions have resulted in the deposition of an unquantified amount of miscellaneous debris on downrange lands. Items could include steel drums and refuse from abandoned camps, and mining operations. Much of this debris is expected to have originated prior to 1980 when ANILCA provided additional protections to much of the PFRR launch corridor.

4.15.12.2 *Future Impacts*

PFRR Actions

Spent Stages and Payloads – Under the No Action Alternative, taking into account the materials associated with an average of four launches per year and the removal of one payload per year, a net quantity of approximately 2,400 kilograms (5,300 pounds) of material would be deposited annually in downrange lands outside of the Poker Flat North and South Special Use Areas (see Section 4.12 for details on the number of payloads and spent stages recovered under each alternative). Under Alternatives 1 and 3, a net quantity ranging from a 500 kilogram (1,100 pounds) reduction up to a 900 kilogram (2,000 pounds) increase could occur within the these same lands. Under Alternatives 2 and 4, the estimated net change could range from a net reduction of up to 1,200 kilograms (2,650 pounds) or an increase of 100 kilograms (220 pounds); the actual quantity within these ranges would depend upon how successful PFRR would be in locating newly launched items.

Launch Support Items **–** It is expected that meteorological support requirements for future launches would remain the same as in the recent past. As such, low-altitude "chaff," medium- and high-altitude latex balloons would be flown, with the medium- and high-altitude configurations carrying the polystyrene-encased GPS radiosonde sensors. A summary of these items expected to remain in downrange lands is presented below in **Table 4–45**.

Table 4–45. Estimated Weights of Future Launch Support Items in Downrange Lands

Item	Weight Each (kg)	Items Per Launch[a]	Weight Per Year[b] (kg)		Downrange Distance (km)	Landowner
			4 Launches	8 Launches		
"Chaff" Latex Balloon	0.1	120	48	96	50–80	State of AK or BLM
Mid-Altitude Latex Balloon	0.3	10	12	24	80–100	State of AK, BLM, or USFWS Yukon Flats NWR
High-Altitude Latex Balloon	1.2	10	48	96	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items	0.25	20	20	40	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket	6.8	15	408	816	4–5	ADNR Poker Flat North and South Special Use Areas
10-year Summary[b] (kg)						
Latex Balloons			1,080	2,160	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Latex Degradation			(972)	(1,944)		
Net Latex Remaining			108	216	50–160	State of AK, BLM, or USFWS Yukon Flats NWR
Polystyrene Items			200	400	80–160	State of AK, BLM, or USFWS Yukon Flats NWR
Test Rocket			4,080	8,160	4–5	ADNR Poker Flat North and South Special Use Areas

a. Each launch requires 10 days of countdown with a 6-hour launch window.

b. Estimates in this table do not include instances when several launches would occur on the same day, which would reduce the presented weights as launch support items would be "shared" among all those launches.

Note: To convert kilograms to pounds, multiply by 2.2046; kilometers to miles, by 0.6214.

Key: ADNR=Alaska Department of Natural Resources; AK=Alaska; BLM=U.S. Bureau of Land Management; kg=kilograms; km=kilometers; NWR=National Wildlife Refuge; USFWS=U.S. Fish and Wildlife Service.

Actions by Others

Recreational Use – Given the growing recreational user base in downrange lands, it is possible that miscellaneous debris could be deposited in the future; however, it cannot be estimated quantitatively.

Arctic Refuge Revised CCP – An objective of the *Draft Revised Arctic CCP* is to expand the Arctic NWR's efforts to restore sites that have historically been impaired or degraded. Actions include removing trash, barrels and contaminants, rehabilitating extensively impaired camp sites, cleaning up abandoned cabin sites and hunting guide camps; and removing downed civilian aircraft, military aircraft and debris, and items left by NASA SRP **(USFWS 2012)**.

Given the commitment of the Arctic NWR to removing debris from its lands, and the ongoing relationship that NASA, UAF, and USFWS staff have developed in identifying and removing flight hardware from downrange lands, it is expected that the effort would have a long-term beneficial impact on the quantities of waste remaining in downrange lands.

4.15.12.3 *Differences Among Alternatives Under Consideration*

Among the five alternatives, the amount of launch-related waste (*e.g.*, stages, payloads, launch support items) initially deposited in downrange lands would be the same; the key difference is the level of search and recovery planned following a launch. The No Action Alternative would contribute the most to long-term adverse cumulative effects on the deposition of waste on downrange lands because it would not involve search and recovery for either historic or future PFRR-launched flight hardware unless dictated by scientific need. Given the sensitivity of downrange lands, it is expected that continuation of the program under the No Action Alternative could lead to moderate to major effects on these resource areas. Alternative 1 would have lesser effects, as it would entail a formal Recovery Program for all reported items, old and new. Alternative 3, which would extend the restriction on planned impacts to designated Wild and Scenic Rivers within the PFRR launch corridor, would have similar effects to Alternative 1. Alternatives 2 and 4, which would require recovery with consideration only to safety, would likely result in the most waste removed from downrange lands over time, and would likely contribute the least to long-term adverse cumulative effects. **Table 4–46** provides a comparative summary of the estimated weights of sounding rocket-related items in downrange lands at year 10 of the cumulative effects analysis period.

Table 4–46. Estimated Weights of Sounding Rocket-Related Items in Downrange Lands at Year 10 of Cumulative Effects Analysis Period

Spent Rocket Motors and Payloads[a]						
			Alternatives 1 and 3		Alternatives 2 and 4	
Land Parcel	Past and Present	No Action	50% Location Success	100% Location Success	50% Location Success	100% Location Success
ADNR Poker Flat North and South Special Use Areas	116,180	138,180	130,011	130,011	119,011	119,011
White Mountains NRA	15,043	27,243	19,303	13,203	17,463	11,363
Yukon Flats NWR	20,763	27,163	24,492	19,492	21,520	16,520
Arctic NWR	22,025	27,425	23,081	20,381	21,437	18,737
Native Village of Venetie	4,720	4,720	4,720	4,720	3,020	3,020
State of Alaska	4,720	4,720	4,720	4,720	4,720	4,720
Beaufort Sea	13,396	22,276	22,276	22,276	22,276	22,276
Unknown	8,519	8,519	8,519	8,519	8,519	8,519
Total All Areas	**180,365**	**235,245**	**212,121**	**198,321**	**192,966**	**179,166**
Total Interior Lands Only	166,969	212,969	189,845	176,045	170,690	156,890
Total Lands Excluding ADNR Poker Flat North and South Special Use Areas	**50,789**	**74,789**	**59,834**	**46,034**	**51,679**	**37,879**

Launch Support Items Applicable to all Alternatives			
Land Parcel	Latex from Balloons	Polystyrene Items	Test Rocket
ADNR Poker Flat North and South Special Use Areas	0	0	33,456–37,536
State of Alaska East of PFRR, White Mountains NRA, or USFWS Yukon Flats NWR	108–216	981–1,381	0

a. Totals reflect approximately 25,000 kg of stages removed in the past whereas individual land parcels do not; therefore, weights calculated for individual parcels should be considered a maximum case.

Key: ADNR=Alaska Department of Natural Resources; NRA=National Recreation Area; NWR=National Wildlife Refuge; PFRR=Poker Flat Research Range; USFWS= U.S. Fish and Wildlife Service.

4.15.13 Noise

4.15.13.1 *Resource Context*

With the exception of the lands immediately adjacent to Villages, the sounds within the PFRR launch corridor are generally dominated by those produced by natural forces, including wind, flowing water, insects, and wildlife. Transient human-caused noise from aircraft would be highest along well-used river corridors and in areas used as flight paths to common landing areas.

4.15.13.2 *Past and Present Impacts*

PFRR Actions

Past and current launches from PFRR have resulted in temporary noise impacts from both sounding rocket flight and occasional recovery actions. However, as most launches have historically occurred during the winter months, when both recreational and subsistence use, as well as wildlife presence is lowest, adverse impacts have most likely been negligible and short term.

Actions by Others

***General Land Management* –** Landowner and resource agency aviation contributes to occasional disruption of the natural soundscape of downrange lands; however, the effects are temporary.

***Recreational Use* –** The recreational use of ATVs and outboard motors on downrange lands contributes to cumulative noise on downrange lands during non-winter months, particularly on BLM lands where maintained trails are readily available for users. The use of snowmobiles during winter months also produces noticeable anthropogenic noise.

***Interior Oil and Gas Exploration* –** Likely the greatest noise-producing action in the past and present would be associated with Interior Oil and Gas exploration. The airborne transportation of equipment and personnel, as well as the sounds generated from mulching, borehole drilling, and the detonation of small explosive charges, could result in additive impacts when such operations are taking place before, during, or immediately after a launch campaign. However, due to the relatively low extent of the exploration, and that most activities would take place during winter months when ground conditions are most favorable for exploration, additive impacts would be minor and short-term.

4.15.13.3 *Future Impacts*

PFRR Actions

Future sounding rocket launches from PFRR would generate short-term noise during the boost and reentry stages of flight; however, as discussed in Section 4.5, these sounds would be audible to receptors on the ground for less than 1 minute per flight. Also, as launches would be expected to occur during winter months, effects would be negligible. The most notable potential change in future operations would be the greater focus on search and recovery of previously launched stages and payloads and those to be launched in the future, which would occur during non-winter months.

Actions by Others

***Interior Oil and Gas Exploration* –** Similar in nature to the impacts of past operations, future oil and gas exploration could result in additive impacts on noise when such operations were taking place before, during, or immediately after a launch campaign. However, due to the relatively low extent of the exploration, and that most activities would likely take place during winter months when ground conditions were most favorable for exploration (and number of receivers the lowest), impacts would be minor and short-term.

***Arctic Refuge Revised CCP* –** It is expected that where all alternatives under consideration in the *Draft Revised Arctic CCP* would preserve minimal management of lands within Arctic NWR, noise-producing activities would be kept to a minimum, thereby resulting in beneficial long-term effects on the lands' natural soundscape.

***OCS Oil and Gas Leasing* –** Of the projects within the PFRR launch corridor, alternatives under the OCS Oil and Gas Leasing Program in the Beaufort Sea Planning Area could lead to increased noise levels at the northern extent of the PFRR launch corridor from construction, exploration, and processing activities. These activities could result in increased noise levels from construction equipment, compressor stations, other equipment, and increased aircraft activity in that area. However, these noise impacts would not add significantly to the noise impacts associated with continued SRP operations at PFRR because of the great distances between the Beaufort Sea (hundreds of kilometers) and the areas where PFRR launches and search and recovery activities would take place.

4.15.13.4 *Differences Among Alternatives Under Consideration*

Differences in noise impacts from the different alternatives would result primarily from varying levels of search and recovery operations as discussed in Section 4.5. Contributions to cumulative noise impacts from search and recovery operations are expected to be minimal due to the limited frequency and duration of these activities.

In relative terms, Alternative 2 would likely contribute the most to potential cumulative effects on noise because it would entail the greatest recovery effort. Alternative 1 would have lesser effects as it would entail a formal Recovery Program for all reported items, old and new. Alternatives 2 and 4, which would require recovery with consideration only to safety, could result in more frequent low-altitude aircraft flights, more short-term noise, and the potential for recovery-related impacts, such as ground scars or ruts. However, it is expected that more materials would be removed in the long term. Alternative 3, which would extend the restriction on planned impacts to designated Wild and Scenic Rivers within the PFRR launch corridor, and permit an environmentally conscious decisionmaking process to govern recovery decisions, would likely result in the least potential for adverse cumulative effects. The No Action Alternative would contribute the least to adverse cumulative noise impacts due to its very limited search and recovery effort.

4.15.14 Transportation

4.15.14.1 *Resource Context*

Recreational and commercial flights occur in the vicinity of PFRR, including from Fairbanks International Airport. Nearby highways, include Route 2, Airport Way, Robert Mitchell Expressway, and Steese Highway.

4.15.14.2 *Past and Present Impacts*

PFRR Actions

Transportation activities associated with past activities have been minimal due to the limited focus on recovery of stages and payloads and the infrequency of launch material shipments.

Actions by Others

***General Land Management* –** Landowner and resource agency aviation contributes to temporary transportation impacts throughout downrange lands.

***Recreational Use* –** In the vicinity of the PFRR launch corridor, recreational fixed-wing aircraft and helicopter use has occurred and is ongoing. Summer ATV travel has occurred and is ongoing within White Mountains NRA.

***Interior Oil and Gas Exploration* –** The use of fixed-wing aircraft and helicopters to transport equipment and personnel related to oil and gas exploration occurs in the vicinity of the PFRR launch corridor.

4.15.14.3 *Future Impacts*

PFRR Actions

Continuation of sounding rocket launches at PFRR would result in negligible transportation impacts. The possible increase in stage/payload shipments and recovery operations would not result in any additional impacts.

Actions by Others

***Interior Oil and Gas Exploration* –** Similar to the past and present operations, future oil and gas exploration would not result in any additional impacts.

***Arctic Refuge Revised CCP* –** The alternatives evaluated in the *Draft Revised Arctic CCP* would allow commercial transportation companies that provide visitor access to Arctic NWR to continue doing so **(USFWS 2011c)**. Flights of fixed-wing aircraft and helicopters in support of activities associated with PFRR would not impact other transportation activities being conducted in Arctic NWR.

***OCS Oil and Gas Leasing* –** The alternatives evaluated in the *OCS Oil and Gas Draft PEIS* **(USDOI 2011e)** would include the construction of additional roads and port facilities. However, these transportation infrastructure improvements would not impact transportation activities associated with PFRR operations and launches. PFRR would remain inaccessible similar to current conditions, and aircraft would still be used for search and recovery activities. PFRR transportation activities would have negligible impacts, as determined in Section 4.11.

4.15.14.4 *Differences Among Alternatives Under Consideration*

The No Action Alternative would provide the smallest transportation impacts because there would be no change to PFRR operations. Alternatives 1 and 3 would result in a negligible increase in fatal accidents due to the increased amount of search and recovery operations. Alternatives 2 and 4 would increase the number of search and recovery operations; however, they would also result in a negligible increase in fatal accidents.

4.16 THE RELATIONSHIP BETWEEN THE SHORT-TERM USES AND LONG-TERM MAINTENANCE AND ENHANCEMENT OF THE ENVIRONMENT

The past, current, and future conduct of the NASA SRP activities at PFRR is a scientific endeavor designed to increase the depth of knowledge of near-space, the Earth's atmosphere, and outer space. This activity enhances the ability to protect the environment through technological means.

The short- and long-term outputs resulting from the NASA SRP activities at PFRR have a positive impact on the understanding of the physical environment in the near-space and the atmosphere. In general, the launch and recovery processes represent relatively minor transient effects. The results of the scientific experiments in the near-space and atmosphere, on the other hand, are making contributions to the protection of the environment.

It is impractical to itemize all known and potential benefits generated by past or planned sounding rocket activities, but the general value can be expressed simply as follows. It is clear that practical and cost-effective means for protecting the environment can be developed only on the basis of knowledge and understanding of the physical, chemical, and biological processes affecting such an environment. Scientifically, more has been learned about the immediate environment and that of the solar system in the last two decades than in all the previous decades combined. Specifically, the NASA SRP makes unique contributions to the total effort to provide an operational capability to measure, monitor, and manage environmental conditions and natural resources from a local to global scale. Launches from PFRR play a significant role in these contributions, including:

1. Serving as a test bed for development of instruments and measurement techniques in a hostile environment (*e.g.,* vacuum, rocket launch vibrations, and temperature extremes). In fact, instruments developed in whole or in part on sounding rockets have later been used on satellites, space shuttles, and space probes.

2. Providing a short lead time capability in flight preparation for observing short-term and sudden events.

3. Providing opportunities for university research groups to perform space science research, for graduate student training, and for beneficial international scientific cooperation in the space area.

In fulfilling its responsibility, the NASA SRP has followed a philosophy that has emphasized safety and economy in conducting these experiments, both in near-space and in the near and far reaches of the atmosphere. At the same time, the NASA SRP has provided a relatively inexpensive approach to partial satisfaction of the fundamental need to better understand, utilize, predict, and control the life-sustaining, and sometimes hostile, environment.

In summary, NASA acknowledges the sensitive environmental context within which it must conduct its operations at PFRR. While doing so, NASA also acknowledges that due to the number of challenges it faces in locating the relatively small items within a large area, it is probable that not all items launched from PFRR (either from the past or future) can be recovered. Therefore, there could be a long-term deposition of flight hardware within these lands for years to come. However, by implementing programmatic commitments to improving location technologies, establishing a recovery budget, and expeditiously removing items that are reported, NASA expects that in the future such impacts would be measurably reduced. Additionally, as supported by the analyses in this EIS, the potential impacts of the SRP on the physical and biological resources of downrange lands are generally negligible to minor. As such, NASA is confident that although there are unavoidable short- and long-term impacts on environmental resources, conducting the science enabled at PFRR would contribute a net benefit to the overall maintenance and enhancement of the environment.

4.17 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The continuation of the NASA SRP at PFRR would result in an irreversible and irretrievable commitment of small quantities of structural materials and propellants. Materials such as aluminum, nickel, stainless steel, carbon, copper, titanium, and other metallic and plastic components are used in the fabrication of rocket propulsion systems and payloads. The propellants used in these rockets are synthetic organic and inorganic compounds.

The total SRP rocket launch activity at PFRR over the last 10 years resulted in the consumption of 35,000 kilograms (77,000 pounds) of structural materials and 51,000 kilograms (110,000 pounds) of propellants. This level of consumption corresponds roughly to materials used in the manufacturing of 22 standard size automobiles and a 10-year fuel equivalent (as mass) for maintaining 15 automobiles. It is not considered to be substantial in terms of use of natural resources.

Search and recovery activities by airplanes, helicopters, and trucks under each of the alternatives evaluated in this *PFRR EIS* would require the consumption of fossil fuels. Fossil fuel that would be consumed annually ranges from 3,070 liters (810 gallons) under the No Action Alternative to 35,000 liters (9,300 gallons) under Alternatives 2 and 4.

Use of military surplus solid propellant rockets, such as Orion, Talos, Taurus, Terrier, and Aries, in the NASA SRP activities further reduces the commitment of new raw materials and provides for the beneficial use of already expended resources that might otherwise become hazardous waste. Consequently, the continuation of the NASA SRP will not commit expenditures of natural resources in substantial quantities.

4.18 SUMMARY OF MITIGATION MEASURES

This section summarizes the mitigation measures and operating procedures that would be used to avoid or reduce potential environmental impacts that may result from implementation of the alternatives analyzed in this EIS. As specified in the CEQ's NEPA regulations **(40 CFR 1508.20)**, mitigation includes:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

All of the alternatives evaluated in detail in this EIS have the potential to cause adverse impacts on one or more resource areas. However, based upon the analyses in this chapter, only the No Action Alternative could potentially result in significant impacts on land use and waste management. The key factor contributing to the magnitude of these impacts is that recovery of flight hardware would only be conducted if dictated by scientific need.

Therefore, in response to concerns raised by agencies and members of the public during scoping, and to the findings of this EIS regarding the No Action Alternative, NASA has included mitigation measures as integral components of Alternatives 1–4. These measures, described in detail in Chapter 2, Section 2.3, and Appendix G, provide consideration of all resource areas while focusing primarily on the location and removal of past and future flight hardware from downrange lands. **Table 4–47** provides a summary of mitigation measures that would be undertaken under the alternatives.

In addition to the mitigation measures NASA would implement to reduce the potential for flight hardware to remain in downrange lands, NASA would continue to follow the requirements levied on its operations by downrange landowners. Summarized in **Table 4–48** are those notable requirements from the most recent permits and authorizations. The full details of landowner-imposed requirements are available in Chapter 2, Section 2.1, and Appendix C. It is possible that landowners could modify permit conditions in the future, and thereby levy additional requirements. In that instance, NASA would continue to work with downrange landowners to ensure that its operations are consistent with the requirements of future authorizations.

Table 4–47. Mitigation Measures Summarized by Alternative

Alternatives 1 through 4
Development of a formal Recovery Program that includes: • Programmatically committing to continually improving recovery aides • Establishing a minimum $250,000 annual recovery budget • Searching for all newly launched, land-impacting stages and payloads • Recovering those items that can be done so in a safe (Alternative 2) and environmentally responsible manner (Alternative 1) • Employing the least tools necessary for the recovery • Engaging outside parties in recovery efforts through an improved, ongoing outreach campaign • Establishing a Rewards Program for persons reporting items in downrange lands • Prioritizing recovery efforts and funding such that items within the most sensitive areas (e.g., Wilderness, Wild and Scenic Rivers) are recovered first • Establishing and maintaining a database to track impact location information for future and past (as available) launches
Alternatives 3 and 4
• Limiting trajectories of future missions such that no planned impact points can be within designated Wild or Scenic River corridors

Table 4–48. Landowner Requirements

All Alternatives

• Notifying landowners and users of planned launch and recovery activity
• Avoiding launches and recovery operations during the most sensitive times of year and/or locations
  o Avoiding launches between May 1 and September 30 unless special authorization is granted
  o Avoiding known raptor nest locations during recovery
  o Avoiding planned impacts within Mollie Beattie Wilderness Area
  o Conducting off-highway moves within existing trails or during winter months
• Protecting natural, cultural, and subsistence resources
  o Maintaining a flight elevation of greater than 2,000 feet above ground level unless actively searching for an item
  o Operating aircraft in a manner that does not harass wildlife
  o Limiting clearing of vegetation to hand-clearing incidental to recovery
  o Filling in excavated areas with native soil or rock materials
  o Avoiding disturbance to subsistence activities and cultural and historic resources
  o Cleaning equipment regularly to minimize the potential spread of noxious or invasive species

CHAPTER 5

AGENCIES, ORGANIZATIONS, AND PERSONS CONSULTED

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5. AGENCIES, ORGANIZATIONS, AND PERSONS CONSULTED

5.1 INTRODUCTION

The National Environmental Policy Act (NEPA) states, "There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to the proposed action." As such, the National Aeronautics Space Administration (NASA) has engaged stakeholders and the general public in the preparation of this Environmental Impact Statement (EIS). Stakeholders include Federal, state, and local governments; business interests; landowners; residents; and environmental organizations.

This chapter of the *Environmental Impact Statement for the Sounding Rockets Program at Poker Flat Research Range (PFRR EIS)* summarizes the public and agency outreach program NASA has undertaken in support of its continued operations at the Poker Flat Research Range (PFRR).

5.2 COOPERATING AGENCIES

NASA is the Federal agency that funds the launch of sounding rockets from PFRR and is therefore the lead agency for preparation of this EIS. The U.S. Department of the Interior's Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service (USFWS), as well as the University of Alaska Fairbanks (UAF) have participated as cooperating agencies in preparing this EIS. As defined in the Title 40 of the *Code of Federal Regulation*s (CFR) Section 1508.5, and further clarified in subsequent Council on Environmental Quality guidance memoranda, a cooperating agency can be any Federal, state, tribal, or local government that has jurisdiction by law or special expertise regarding any environmental impact involved in a proposal or a reasonable alternative.

NASA requested that BLM and USFWS participate as cooperating agencies because they possess both regulatory authority over downrange lands and specialized expertise regarding the environmental context of those lands. UAF was requested to participate given its expertise regarding sounding rocket launches from PFRR. All three cooperating agencies have actively participated throughout the development of this EIS, providing technical review and input as well as facilitating key components of the scoping process, summarized below.

5.3 SCOPING PROCESS

5.3.1 Pre-EIS Scoping

NASA began preparing an environmental assessment (EA) in 2010 to determine if potential changes in either its operations at PFRR or the management of downrange lands presented a significant impact necessitating an EIS. During the scoping process for the EA, in the fall of 2010, NASA solicited input from over 75 potentially interested agencies and organizations.

The comments received while scoping the EA led to NASA's decision to prepare this EIS and were considered in establishing the scope of this document. A summary of the comments received during the 2010 EA scoping process is presented by topic area in Chapter 1, Section 1.4.1, Table 1–2.

In addition to sending letters to potentially interested parties, several meetings were held with BLM, USFWS, and non-governmental organizations before deciding to prepare this EIS.

5.3.2 EIS Scoping

The initiation of the EIS scoping process began with NASA's publication of a Notice of Intent (NOI) in the *Federal Register* on April 13, 2011. The publication of the NOI officially marked the beginning of the scoping period, during which time NASA accepted public input on the proposed action. A copy of the NOI is included in Appendix A.

NASA distributed newspaper and radio advertisements to announce the NOI and the scoping meetings. In addition, NASA distributed a public scoping press release to newspaper, television, and radio channels covering the locations where public scoping meetings were being held.

NASA held five scoping meetings from April 28 through May 3, 2011, in Fort Yukon, Fairbanks, and Anchorage, Alaska to gather community-specific issues and concerns on which to focus the EIS analysis.

In total, NASA solicited input from approximately 140 potentially interested citizens, tribes, agencies, and organizations. Overall, local citizens, tribes and agencies were mostly concerned about the rocket spent stages landing in the wilderness areas, including concerns about physical and chemical impacts, as well as impacts on the wilderness aesthetic values. Commenters also had concerns about the lack of awareness that these rocket launches are ongoing. During the NASA 2010 EA scoping, the public and government agencies raised similar issues, emphasizing concerns about impacts on wilderness areas and wilderness study areas.

A summary of the comments received during the *PFRR EIS* scoping process is presented by topic area in Chapter 1, Section 1.4.2, Table 1–3.

5.4 CONSULTATION WITH TRIBAL GOVERNMENTS

Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*, directs Federal agencies to establish regular and meaningful consultation and collaboration with tribal governments in the development of Federal policies that have tribal implications and to strengthen U.S. government-to-government relationships with American Indian (and Alaska Native) tribes. The Executive Order defines the term tribe as those tribes acknowledged to exist by the Secretary of the Interior as an Indian tribe pursuant to the Federal Recognized Indian Tribe List Act of 1994.

5.4.1 Correspondence

Beginning in April 2011 with the scoping process for this EIS, NASA mailed letters providing project information and offering government-to-government consultation with all potentially affected tribes within and adjacent to the PFRR flight corridor. Included with each letter was a postage-paid consultation questionnaire, which could be used to provide a project point of contact and express the tribe's level of interest in the project. NASA also faxed copies of the project information package to the tribal offices. The nine tribes listed below were sent the letter and questionnaire:

- Beaver Traditional Council, Beaver
- Birch Creek Tribal Council, Birch Creek
- Chalkyitsik Village Council, Chalkyitsik
- Circle Native Community, Circle
- Gwitchyaa Zhee Gwich'in Tribal Government, Fort Yukon
- Naqsragmuit Tribal Council, Anaktuvuk Pass
- Native Village of Kaktovik Council, Kaktovik
- Native Village of Stevens Tribal Government, Stevens Village
- Native Village of Venetie Tribal Government, Venetie

Of the nine tribes, Beaver Traditional Council, Gwitchyaa Zhee Gwich'in Tribal Government, and the Naqsragmuit Tribal Council responded to NASA's request. Beaver Traditional Council indicated that the tribe had no potentially affected interests or concerns regarding the project. The Gwitchyaa Zhee Gwich'in Tribal Government and Naqsragmuit Tribal Council requested to meet with NASA at a tribal facility.

In December 2011, NASA mailed a similar letter and consultation questionnaire to the same nine Ttribes requesting interest in becoming consulting parties during its National Historic Preservation Act review process. Of the nine tribes, Beaver Traditional Council and the Native Village of Venetie Tribal Government responded. Beaver indicated that the tribe did not have any concerns regarding potential effects on properties of cultural significance; Venetie requested to meet with NASA to discuss the project.

5.4.2 Meetings

As a result of the interest expressed in the project, NASA, USFWS, and UAF met with the Gwitchyaa Zhee Gwich'in Tribal Government in April 2011 and the Native Village of Venetie Tribal Government in February 2012. Notices of the meetings were distributed to local venues within the Villages as well as broadcast on the local Yukon Flats radio station, KZPA 900 AM. In addition, NASA personnel participated in a call-in show on KZPA to give an overview of the project and answer questions.

The primary topics of concern expressed in both meetings were that (1) Villages were not well informed of launches; (2) Students from local Villages should be given a tour of PFRR and have the opportunity to explore scientific and engineering fields; (3) Hazardous materials in rockets should be evaluated as they could affect wildlife, and in turn, affect subsistence users; (4) the Rewards Program would be beneficial to Village residents; and (5) Village residents should be employed to assist in searches for rocket hardware.

In addition to the meetings with the tribal governments, NASA, USFWS, and UAF personnel also gave presentations at the Fort Yukon and Venetie schools.

To ensure that all potentially affected tribes are informed of the status of the project, the *PFRR EIS* mailing list includes all nine tribes, who will receive copies of any document distributed to the public, including copies of the draft and final EIS.

NASA recognizes that the government-to-government consultation process is ongoing and will continue to engage in written and phone communications directed specifically to the Tribes to encourage their engagement at any time. Additional meetings will be scheduled as requested.

5.5 RELATED ENVIRONMENTAL REVIEWS

NEPA states that to the fullest extent possible, Federal agencies should prepare EISs concurrently with and integrated with other related environmental review processes. While preparing this EIS, NASA strived to accomplish as many related environmental review requirements as practicable to assist in the decisionmaking process. Consultations pursuant to the Coastal Zone Management Act, Endangered Species Act, Magnuson-Stevens Fishery Conservation and Management Act, and National Historic Preservation Act are being accomplished concurrently with EIS preparation. Summaries of the status of these consultations are included below. Please note that this section is not intended to be a compendium of all applicable environmental requirements; rather, its purpose is to provide a summary of those consultations most relevant to NASA's operations at PFRR.

5.5.1 Endangered Species Act

Section 7 of the Endangered Species Act of 1973 requires Federal agencies to consult with USFWS or the National Oceanic Atmospheric Administration Fisheries Service (collectively, the Services) to ensure that actions do not jeopardize threatened or endangered species or result in the destruction or adverse modification of critical habitat.

In April 2011, NASA requested lists of protected species or critical habitat within the PFRR launch corridor; the Services provided the requested information (see Appendix A). NASA then prepared a Biological Assessment to determine whether its operations at PFRR may affect those species or habitat (Appendix H). For those species and habitat that NASA determined may be affected, NASA requested concurrence from the Services that the effects would not likely be adverse. USFWS concurred with NASA's determination and NOAA's Fisheries concurrence is still pending. The outcome of NOAA's determination will be summarized in the Final *PFRR EIS*.

5.5.2 National Historic Preservation Act

The National Historic Preservation Act of 1966, as amended, contains procedures for evaluating historic properties, consulting with interested parties, and protecting and preserving cultural resources. Section 106 of the National Historic Preservation Act requires review of any project funded, licensed, permitted, or assisted by the Federal Government for impact on significant historic properties. Federal agencies must consult with the State Historic Preservation Officer, tribes, the Advisory Council on Historic Preservation (ACHP), and other interested parties.

During the 2011 scoping process for this EIS, NASA requested input regarding concerns about impacts on areas of cultural significance from the nine Federally recognized tribes within and adjacent to the PFRR launch corridor. Of the two tribes that responded, NASA held a meeting with the Gwitchyaa Zhee Gwich'in Tribal Government in Fort Yukon. At that meeting, no specific concerns regarding historic properties were raised.

Following this request, NASA engaged the Alaska Division of History and Archaeology and ACHP to discuss the Section 106 process for the project. ACHP accepted NASA's request to participate in the consultation.

In December 2011, requests for interest in serving as consulting parties were mailed to potentially interested tribal, cultural, and local government organizations. Following this request, NASA received a response from the Native Village of Venetie Tribal Government and the City of North Pole. NASA met directly with the tribal government to discuss its concerns; those discussions are summarized above and did not identify specific concerns regarding historic properties. The City of North Pole indicated that it did not have any concerns regarding potential effects on cultural resources specifically; however, the city wished that all valid concerns be addressed though NASA's environmental review process. In May 2012, Doyon, Limited expressed an interest in meeting with NASA regarding the Section 106 process. NASA is currently working to schedule a teleconference with Doyon at a mutually agreeable time. Section 106 consultation is provided in Appendix A, Section A.2. The Alaska Historic Preservation Officer concurred that no historic properties would be affected.

5.5.3 Coastal Zone Management Act

Section 307(c) of the Coastal Zone Management Act of 1972, as amended, states, "each Federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved State coastal management programs." Federal agency consistency requirements are addressed in 15 CFR 930.

The Alaska Coastal Management Program was terminated on July 1, 2011, per Alaska 44.66.030. Prior to its termination, NASA contacted the Alaska Coastal Management Program in April 2011 and was informed that a consistency determination would not be required for the alternatives under consideration in this EIS. Therefore, no additional coordination regarding coastal zone management is needed.

5.5.4 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 1976 established eight regional Fishery Management Councils responsible for the protection of marine fisheries. A 1996 amendment to MSFCMA instituted a new mandate to identify and provide protection to important marine and anadromous fisheries habitat, or essential fish habitat (EFH). EFH is defined in the MSFCMA as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity." "Fish" is defined as finfish, crabs, shrimp, and lobsters. MSFCMA specifies that a Federal agency shall consult with the National Marine

Fisheries Service (NMFS) when proposing any activity that may adversely affect designated EFH.

Although designated EFH lies within the PFRR launch corridor, NASA has determined that none of the alternatives presented in this EIS would adversely affect EFH. Therefore, no consultation with the NMFS regarding EFH is required.

5.6 WEB SITE

Throughout the duration of the *PFRR EIS* NEPA process, NASA has maintained a website that provides the public with the most up-to-date project information, including electronic copies of the EIS, as they are available. The website may be accessed at http://sites.wff.nasa.gov/code250/pfrr_eis.html.

5.7 REVIEW OF DRAFT EIS

The public will be notified of the opportunity to review and comment on this Draft *PFRR EIS* by announcements in the *Federal Register* and local news media. This Draft *PFRR EIS* will also be available for public review at the following locations:

ARLIS

Library Building, Suite 111
3211 Providence Drive
Anchorage, AK 99508
Phone: (907) 272-7547
Hours: Mon–Fri: 8 a.m. to 5 p.m.

Elmer E. Rasmuson Library

University of Alaska Fairbanks
310 Tanana Loop
Fairbanks, AK 99775
Phone: (907) 474-7481
Hours: variable, call to confirm

Juneau Public Library

Downtown Branch
292 Marine Way
Juneau, AK 99801
Phone: (907) 586–5249
Hours: Mon–Thur: 11 a.m. to 8 p.m.
Fri: 12 p.m. to 6 p.m.
Sat and Sun: 12 p.m. to 5 p.m.

NASA Headquarters Library

300 E Street SW, Suite 1J20
Washington, DC 20546
Phone: (202) 358-0168
Hours: Mon–Fri: 7:30 a.m. to 5:00 p.m.

Noel Wien Library

1215 Cowles Street
Fairbanks, AK 99701
Phone: (907) 459-1020
Hours: Mon–Thur: 10 a.m. to 9 p.m.
Fri: 10 a.m. to 6 p.m.
Sat: 10 a.m. to 5 p.m.
Sun: 1 p.m. to 5 p.m.

Z.J. Loussac Public Library

3600 Denali Street
Anchorage, AK 99503
Phone: (907) 343-2975
Hours: Mon–Thur: 10 a.m. to 9 p.m.
Fri and Sat: 10 a.m. to 6 p.m.
Sun: 1 p.m. to 5 p.m.

5.8 DRAFT EIS DISTRIBUTION LIST

Copies of this Draft *PFRR EIS* have been sent directly to the stakeholders listed below:

Alaska Native Corporations

Arctic Slope Regional Corporation

Beaver Kwit'chin

Chalkyitsik Native Corporation

Danzhit Hanlaii Corporation

Dinyea Corporation

Doyon, Limited

Kaktovik Inupiat Corporation

Nunamiut Corporation

Tiheet'Aii Incorporated

Alaska Native Governments and Organizations

Alaska Federation of Natives

Alaska Inter-Tribal Council

Arctic Village Council

Beaver Traditional Council

Bering Sea Council of Elders

Birch Creek Tribal Council

Canyon Village Traditional Council

Chalkyitsik Village Council

Circle Native Community

Council of Athabascan Tribal Governments

Gwichyaa Zhee Gwich'in Tribal Government

Inuit Circumpolar Council

Naqsragmuit Tribal Council

Native Village of Kaktovik Council

Native Village of Stevens Tribal Government

Native Village of Venetie Tribal Government

Regional Native Health Corporation

Tanana Chiefs Conference

Venetie Village Council

Yukon River Inter-Tribal Watershed Council

Business and Industry

Alaska Commercial Company

Chatanika Lodge

Coyote Air Service

Doyon Emerald

Oasis Environmental

Quicksilver Aviation

Shadow Aviation

URS Corporation

Warbelow's Air Ventures

Willow Environmental, LLC

Wright Air Service

Elected Officials

Honorable Alan Dick, Alaska House of Representatives

Honorable Albert Kookesh, Alaska State Senate

Honorable David Guttenberg, Alaska House of Representatives

Honorable Don Young, U.S. House of Representatives

Honorable Donald Olson, Alaska State Senate

Honorable Joe Paskvan, Alaska State Senate

Honorable Lisa Murkowski, U.S. Senate

Honorable Mark Begich, U.S. Senate

Honorable Reggie Joule, Alaska House of Representatives

Honorable Sean Parnell, Governor of Alaska

Federal Government

Advisory Council on Historic Preservation

Bureau of Indian Affairs

Bureau of Land Management

Bureau of Ocean Energy Management

Bureau of Safety and Environmental Enforcement

Federal Aviation Administration

Federal Subsistence Board

National Marine Fisheries Service

National Park Service

Natural Resources Conservation Service, Alaska State Office

U.S. Air Force, Eielson Air Force Base

U.S. Air Force, Elmendorf Air Force Base

U.S. Arctic Research Commission

U.S. Army Corps of Engineers

U.S. Army, Fort Wainwright

U.S. Coast Guard

U.S. Department of the Interior, Office of Environmental Policy and Compliance

U.S. Environmental Protection Agency

U.S. Fish and Wildlife Service

U.S. Forest Service

U.S. Geological Survey

Local Government

City of Allaket

City of Anaktuvuk Pass

City of Anchorage

City of Fairbanks

City of Fort Yukon

City of Kaktovik

City of North Pole

Fairbanks North Star Borough

North Slope Borough

State Government

Alaska Department of Environmental Conservation

Alaska Department of Fish and Game, Division of Wildlife Conservation

Alaska Department of History and Archaeology

Alaska Department of Natural Resources, Division of Coastal and Ocean Management

Alaska Department of Natural Resources, Division of Planning

Organizations

Alaska Air Carriers Association

Alaska Center for the Environment

Alaska Conservation Alliance

Alaska Conservation Foundation

Alaska Migratory Bird Co-Management Council

Alaska Oceans Program

Alaska Wildlife Alliance

Alaska Women’s Environmental Network

Audubon Alaska

Center for Biological Diversity

Defenders of Wildlife

Ducks Unlimited

Foundation of North America, Alaska Chapter

Friends of Alaska National Wildlife Refuges

National Wildlife Federation

National Wildlife Refuge Association

Natural Resources Defense Council

North Pacific Fishery Management Council

North Slope Science Initiative

North Slope Subsistence Advisory Council

Northern Alaska Environmental Center

Porcupine Caribou Management Board

Sierra Club

The Conservation Fund

Organizations (*continued*)

The Nature Conservancy

The Wilderness Society

The Wildlife Society

Trustees for Alaska

Wilderness Watch

Winter Wildlands Alliance

Yukon Flats Resource Conservation and Development

Yukon River Drainage Fisheries Association

Individuals

Macgill Adams

Lee Boswell

Charles Donahue

Michael Farrell

Frank Keim

Adrienne Lindholm

Brad Meiklejohn

Allen Smith

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CHAPTER 6

LIST OF PREPARERS

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6. LIST OF PREPARERS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WALLOPS FLIGHT FACILITY

Brinton, John
Sounding Rockets Program Grants Management Specialist
EIS Responsibilities: Review, description of Sounding Rockets Program
Education: B.S., Business Administration, University of Baltimore
Experience: 32 years

Bundick, Joshua
Lead, Environmental Planning
EIS Responsibilities: Government Project Manager, review, alternatives, cumulative effects
Education: B.A., Environmental Sciences, University of Virginia
Experience: 10 years

Hickman, John
Sounding Rockets Program Operations Manager
EIS Responsibilities: Sounding Rockets Program liaison, review, alternatives, recovery plan
Education: B.S., Physics, Salisbury University
Experience: 27 years

Skees, Ira
Flight Safety Analyst
EIS Responsibilities: Safety, risk assessment
Education: B.S., Mechanical Engineering and Mechanics, Old Dominion University
Experience: 26 years

Stanley, Randall
Historic Preservation Officer
EIS Responsibilities: Review, cultural resources consultations
Education: B.S., Architectural Engineering Technology, Fairmont State College
Experience: 3 years

GODDARD SPACE FLIGHT CENTER

Pfaff, Robert
Research Astrophysicist and Chairman of Sounding Rockets Working Group
EIS Responsibilities: Purpose and need, review
Education: Ph.D., Cornell University
D.E.S., University of Paris
A.B., Brown University
Experience: 37 years

HEADQUARTERS

Groman, Jennifer
Agency Cultural Resources Manager

EIS Responsibilities:	Review, cultural resources consultations
Education:	M.A., Architecture, University of Texas at Austin
	B.A., Architecture, Yale University
Experience:	25 years

Norwood, Tina
Agency NEPA Manager

EIS Responsibilities:	Review
Education:	M.S., Ecology, Texas A&M University
	B.S., Animal Science, University of Maryland
Experience:	25 years

U.S. BUREAU OF LAND MANAGEMENT

EASTERN INTERIOR FIELD OFFICE

Heppler, Lenore
Field Office Manager

EIS Responsibilities:	Review
Education:	B.S., Natural Resources Management, Ohio State University
Experience:	28

U.S. FISH AND WILDLIFE SERVICE

ARCTIC NATIONAL WILDLIFE REFUGE

LaRosa, Anne Marie
Deputy Refuge Manager

EIS Responsibilities:	Review; Section 1002 of ANILCA/Wilderness language pertaining to Arctic Refuge
Education:	M.S., Plant Ecology
Experience:	30 years

Voss, Richard
Refuge Manager

EIS Responsibilities:	Review
Education:	B.S., Biology
Experience:	37 years

YUKON FLATS NATIONAL WILDLIFE REFUGE

Bertram, Mark
Wildlife Biologist
EIS Responsibilities: Review; facilitate government to government consultations and scoping in Alaska villages; guidance for recovery program to meet Refuge requirements
Education: B.S., Wildlife Management, University of Missouri
Experience: 25 years

Brown, Wennona
Former Deputy Refuge Manager
EIS Responsibilities: Review; facilitate government to government consultations and scoping in Alaska villages; guidance for recovery program to meet Refuge requirements
Education: M.A., Pubic Administration, Ohio State University
M.S., Wildlife Science, Texas A&M University
B.S., Biology/English, Texas Wesleyan College
Experience: 22 years

Jess, Robert
Former Refuge Manager
EIS Responsibilities: Review; facilitate government to government consultations and scoping in Alaska villages; guidance for recovery program to meet Refuge requirements
Education: B.S., Fisheries and Wildlife Management, Utah State University
Experience: 18 years

REFUGE PLANNING AND POLICY

Wikoff, Peter
Natural Resource Planner
EIS Responsibilities: Liaison between U.S. Fish and Wildlife Service and other entities; review materials for consistency with agency requirements
Education: B.S., Forest Management, Colorado State University
Experience: 38 years

UNIVERSITY OF ALASKA FAIRBANKS

Conde, Mark
Professor and Poker Flat Research Range Project Scientist
EIS Responsibilities: Purpose and need, review
Education: Ph.D., Physics, University of Adelaide (Australia)
B.S., Physics, University of Tasmania
Experience: 29 years

Rich, Kathe
Poker Flat Research Range Operations Controller

EIS Responsibilities:	Review, recovery plan
Education:	B.S., Natural Resource Management, University of Alaska Fairbanks
Experience:	22 years

CLEMSON UNIVERSITY

Larsen, Miguel
Professor and Poker Flat Research Range Project Scientist

EIS Responsibilities:	Purpose and need, review
Education:	Ph.D., Physics, Cornell University M.S., Cornell University B.S., University of Rochester
Experience:	34 years

COMPUTER SCIENCES CORPORATION

Choquette, Richard
Flight Safety Analyst

EIS Responsibilities:	Analysis of alternate launch sites and trajectories
Education:	B.S., Engineering, University of Maryland Eastern Shore
Experience:	1 year

LJT AND ASSOCIATES

Bogan, James
Manager, Range Assets Maintenance

EIS Responsibilities:	Radar and telemetry system assessment
Experience:	27 years

Jimmerson, Joseph
Manager, Range Services Office

EIS Responsibilities:	Radar and telemetry system assessment
Education:	M.A.S., Embry-Riddle Aeronautical University B.S., Russian History, U.S. Air Force Academy
Experience:	13 years

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Austin, John

EIS Responsibilities:	*Noise*
Education:	B.A., Biology and Environmental Sciences, University of Virginia
Experience:	11 years

Baxter, Rachel
EIS Responsibilities: *Appendix D Manager, Subsistence and ANILCA*
Education: B.A., Economics, University of Colorado
Experience: 7 years

Crede, Suzanne
EIS Responsibilities: *Project Manager*
Education: M.A., Counseling and Guidance, West Virginia University
B.S., Chemistry, General Science, and Safety Education, West Virginia University
Experience: 22 years

Eichner, John
EIS Responsibilities: *Chapter 4 Manager*
Education: B.S., Accounting, Syracuse University
B.S., Finance, Syracuse University
Experience: 30 years

Gindle, Donna
EIS Responsibilities: *Public Outreach*
Education: M.A., Professional Communication, University of Alaska Fairbanks
B.A., Journalism, University of Alaska Fairbanks
Experience: 28 years

Gorden, Milton
EIS Responsibilities: *Transportation*
Education: B.S., Nuclear Engineering, North Carolina State University
Experience: 22 years

Greene, Aaron
EIS Responsibilities: *Ecological Resources, GIS Support*
Education: M.S., Environmental Science, Indiana University
B.S., Environmental Science, Mansfield University
Experience: 10 years

Gross, Lorraine
EIS Responsibilities: *Cultural Resources*
Education: M.A., Anthropology, Washington State University
B.A., Anthropology, Pomona College
Experience: 32 years

Hiller-LaSalle, Deborah
EIS Responsibilities: *Public Outreach* and *Regulatory Support*
Education: J.D., University of Utah Law School
B.S., Chemistry, University of Idaho
Experience: 16 years

Holian, James
EIS Responsibilities: *Meteorology*
Education: M.S., Meteorology, Pennsylvania State University
B.S., Meteorology, Pennsylvania State University
Experience: 28 years

Minichino, Brian
EIS Responsibilities: *Recovery Scenarios for Rocket Stages and Payloads*
Education: B.S., Chemistry, Virginia Polytechnic Institute and State University
Experience: 4 years

Mulroy, Thomas
EIS Responsibilities: *Biological Resources Lead*
Education: Ph.D., Ecology and Evolutionary Biology, University of California Irvine
M.S., Biology, University of Arizona
B.A., Zoology, Pomona College
Experience: 35 years

Outlaw, Douglas
EIS Responsibilities: *Deputy Project Manager, Chapters 1 and 2 Manager, Human Health and Safety, Trajectories*
Education: Ph.D., Physics, North Carolina State University
M.S., Physics, North Carolina State University
B.S., Physics, North Carolina State University
Experience: 37 years

Preston, Margaret
EIS Responsibilities: *GIS Support*
Education: B.S., Environmental Science, University of Maryland Baltimore County
Experience: 7 years

Rainer, Michael
EIS Responsibilities: *Water Resources and Geology and Soils*
Education: B.S., Agronomy-Soils, Louisiana Tech University
Experience: 15 Years

Robinson, Linda
EIS Responsibilities: *Project Quality Advisor*
Education: Executive M.B.A., Loyola College
B.S. Ed., Earth Sciences, Texas Christian University
Experience: 39 years

Schatzel, Sean
EIS Responsibilities: *Socioeconomics, Environmental Justice*
Education: B.A., Political Economics/Public Administration, Bloomsburg University
Experience: 6 years

Stork, Allison

EIS Responsibilities:	*Waste Management*
Education:	M.S., Geography, University of Tennessee B.A., Geography, State University of New York at Geneseo B.A., English, State University of New York at Geneseo
Experience:	6 years

Upchurch, Audra

EIS Responsibilities:	*Chapter 3 Manager, Appendix C Manager, Land Use and Recreation, Visual Resources*
Education:	M.N.R., Natural Resources, Virginia Polytechnic Institute and State University B.S., Forestry, Virginia Polytechnic Institute and State University
Experience:	13 years

Werth, Robert

EIS Responsibilities:	*Air Resources and Noise*
Education:	B.A., Physics, Gordon College
Experience:	38 years

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CHAPTER 7

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CHAPTER 8

GLOSSARY

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8. GLOSSARY

Adsorption – The retention of molecules, atoms, or ions on the surface of a solid or liquid.

Aeolian – Giving forth or marked by a moaning or sighing sound or musical tone produced by or as if by the wind.

Aerodynamic Heating – Heating as a result of motion through air or other gaseous fluids.

Aeronautical – Dealing with the operation of aircraft.

Alluvial – Relating to, composed of, or found in clay, silt, sand, gravel, or similar detrital material deposited by running water.

Aquifer – A water-bearing layer of permeable rock, sand, or gravel.

Apogee – Highest point or apex in the suborbital path followed by a launch vehicle before it reverses direction and returns to Earth.

Attitude Control System – An arrangement of controlled thrusters attached to space objects, such as optical instruments, to align them accurately on celestial bodies by releasing compressed fluids or gases.

Azimuth – Horizontal direction expressed as the angular distance between the direction of a fixed point (as the observer's heading) and the direction of the object.

Ballistic – Path of a moving aerial projectile with no on-board propulsion based on gravity and air resistance, *e.g.*, path of a spent rocket after burnout.

Bioavailability – The degree and rate at which a substance (as a drug) is absorbed into a living system or is made available at the site of physiological activity.

Cloud nucleation – The process by which water droplets are formed in water vapor on the surface of particles, resulting in cloud formation.

Colluvial – Relating to, composed of, or found in rock detritus and soil accumulated at the foot of a slope.

Criteria Pollutant – Air pollutants regulated by the EPA by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. (based on http://www.epa.gov/air/urbanair/)

Critical Habitat – (1) specific areas within the geographical area occupied by a species at the time it is listed (as endangered or threatened) on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

Crossrange – Lateral of a launching site.

Curie – A unit of radioactivity equal to 3.7×10^{10} disintegrations per second.

Diffusion – Spreading of emitted matter into the atmosphere from a stationary or moving source, determined by physical and chemical properties of the emission and by site specific conditions, such as altitude, wind, and weather.

Diffusion Model – A method of calculating parameters of diffusion, such as concentrations of emitted substances, over geographical areas of interest and time, for comparison with allowable exposure limits.

Dispersion – Deviation of actual impact range of a spent rocket from the predicted location, usually broken down into downrange and crossrange components.

Downrange – Away from a launching site.

Ecoregion – A geographical area distinguished from others by a unique combination of land-surface form, climate, vegetation, soils, and fauna. (based on http://www.fws.gov/wetlands/_documents/gNSDI/DescriptionEcoregionsUnitedStates.pdf)

Emission – Addition to the atmosphere of foreign matter from stationary or moving sources, *e.g.*, rocket exhaust from a sounding rocket in its trajectory, or from a stationary rocket firing.

Endangered – Any species that is in danger of extinction throughout all or a significant portion of its range.

Fallout – The descent of objects or particles through the atmosphere.

Forb – An herb other than grass.

Glaciofluvial – of, relating to, or coming from streams deriving much or all of their water from the melting of a glacier.

Global Warming – Theory which states that an increase in carbon dioxide and other gases in the atmosphere results in an additive effect on average global temperatures.

GPS – Global positioning system.

Graminoid – Of or relating to grasses.

Greenhouse Effect – The effect of carbon dioxide and other gases in the atmosphere which act like glass in a greenhouse, trapping some of the solar heat which otherwise would be radiated back to space.

Inversion – A departure from the usual decrease or increase of the value of an atmospheric property, most commonly temperature, with altitude.

Impact Range – Horizontal distance along the Earth's surface from the launch point of a launch vehicle to the landing point of the payload or a spent rocket. Usually used to denote the maximum horizontal distance traveled by a launch vehicle, i.e., the distance to the landing point of the payload or spent final rocket stage.

Infrastructure – The system of public works of a country, state, or region; *also*: the resources (as personnel, buildings, or equipment) required for an activity.

In situ – In the natural or original position or place.

Ionosphere – Atmospheric layer from about 80 kilometers to beyond 1,000 kilometers (50 miles to beyond 621 miles).

Launch Vehicle – A stacked assembly of one or more cylindrical rockets in series, topped by a cylindrical payload and a nose cone. In the sounding rocket application, the payload consists of scientific instruments either gathering in situ samples or making optical observations of terrestrial (atmospheric), planetary, solar system or galactic targets.

LIDAR – Technique for determining the distance to an object by transmitting a laser beam, usually from an airplane, at the object and measuring the time the light takes to return to the transmitter. From *li*ght *d*etection *a*nd *r*anging.

Logarithmic Scale – Scale based on the exponent that indicates the power to which a base number is raised to produce a given number.

Magnetosphere – A region of space surrounding a celestial object (as a planet or star) that is dominated by the object's magnetic field so that charged particles are trapped in it.

Mechanical Forcing – Creation or delegation of motion or agitation through physical interaction.

Mesic – Characterized by, relating to, or requiring a moderate amount of moisture.

Mesosphere – Atmospheric layer from about 50 kilometers to about 80 kilometers (31 miles to about 50 miles).

Meteorological – Dealing with the Earth's atmosphere and its phenomena, and especially with weather and weather forecasting.

Mitigation – In relation to environmental impacts this includes (1) avoiding the impact altogether by not taking an action; (2) minimizing impacts by limiting an action; (3) rectifying the impact by repairing or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation/maintenance operations during the life of the action; (5) compensating for the impact by replacing or providing substitute resources or environments.

Noctilucent – A luminous thin usually colored cloud seen especially at twilight at a height of about 80 kilometers (50 miles).

Parabolic Trajectory – An orbit whose overall shape is like a parabola or u-shape.

Payload – The load carried by a vehicle exclusive of what is necessary for its operation; *especially*: the load carried by an aircraft or spacecraft consisting of things (as passengers or instruments) necessary to the purpose of the flight.

Permafrost – A permanently frozen layer at variable depth below the surface in frigid regions of a planet (as Earth).

Photochemical Oxidation – A chemical reaction is influenced or initiated by light, particularly ultraviolet light.

Programmatic – Relating to the Sounding Rocket Program as a whole, uninfluenced by the launch site, *e.g.*, upper atmosphere impacts.

Proxy – A substitute.

Pyrophoric propellant – A propellant combination of a liquid fuel and a fluid oxidizer (usually air) that will quickly react when brought into contact with one another and achieve ignition temperature.

Pyrotechnic – Of or relating to any of various devices comprised of combustible substances.

Riffle-pool – A shallow area, either natural or manmade, causing broken water and allowing for the precipitation of suspended solids.

Rocket Exhaust – Products of the combustion or burning of a rocket's propellant, collectively called the rocket exhaust or exhaust gases, which flow out of the rocket exit nozzle at supersonic speeds into the surrounding atmosphere.

Site-Specific – Relating to a particular launch site, *e.g.,* impacts affected by geographical location and local climate, fauna and flora.

Solid Propellant – A cured mixture of powdered chemicals, including fuel and oxidizer compounds, and an electrical igniter, formed into cylindrical shape and inserted into the rocket casing. The proportions of the ingredients are selected to provide a given thrust and burning time, but once ignition takes place, the solid propellant combustion cannot be further controlled.

Sounding Rocket – A rocket-propelled suborbital launch vehicle equipped with a scientific payload for making observations from the Earth's atmosphere. The propulsion may be by a single rocket for low apogees or by multiple rockets staged in series to attain higher apogees.

Spent Rocket – Residual casing or shell of a solid propellant rocket after burnout when the propellant has been exhausted and expelled as exhaust gases; follows a ballistic path to ground.

Stage – One of two or more sections of a rocket that have their own fuel and engine.

Stratosphere – Atmospheric layer from about 10 kilometers to about 50 kilometers (6 miles to about 31 miles).

Sub-Orbital – Being or involving less than one orbit (as of the Earth or Moon); also: intended for suborbital flight.

Subsistence – A system or culture of acquiring the minimum (as of food and shelter) necessary to support life from natural resources.

Talik – Unfrozen, subsurface dome-like features which occur in arctic regions.

Telemetry – Data transmitted by telemetry (over distance).

Thermodynamic – Of or relating to the branch of physics that deals with mechanical action or relations of heat.

Thermokarst – land-surface configuration that results from the melting of ground ice in a region underlain by permafrost.

Tundra – A level or rolling treeless plain that is characteristic of arctic and subarctic regions, consists of black mucky soil with a permanently frozen subsoil, and has a dominant vegetation of mosses, lichens, herbs, and dwarf shrubs; also: a similar region confined to mountainous areas above timberline.

Trajectory – Flight path of typical sounding rocket, from surface launch up to apogee and down to surface landing, along an arc of close to parabolic shape.

Threatened – any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Troposphere – Atmospheric layer from surface to about 10 kilometers (6 miles).

Viewshed – The natural environment that is visible from one or more viewing points.

Water-Soluble – Capable of being dissolved by water.

Wetlands – Land or areas, such as tidal flats and swamps, which contain large amounts of soil moisture.

CHAPTER 9

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16 U.S.C. 1361, Marine Mammal Protection Act.

16 U.S.C. 1531, Endangered Species Act.

16 U.S.C. 3120, Subsistence and Land Use Decisions.

25 U.S.C. 3001, Native American Graves Protection and Repatriation Act of 1990.

33 U.S.C. 1251, Clean Water Act of 1977, as amended.

42 U.S.C. 1996, American Indian Religious Freedom Act of 1978.

42 U.S.C. 6901, Solid Waste Act of 1965.

42 U.S.C. 9601, Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

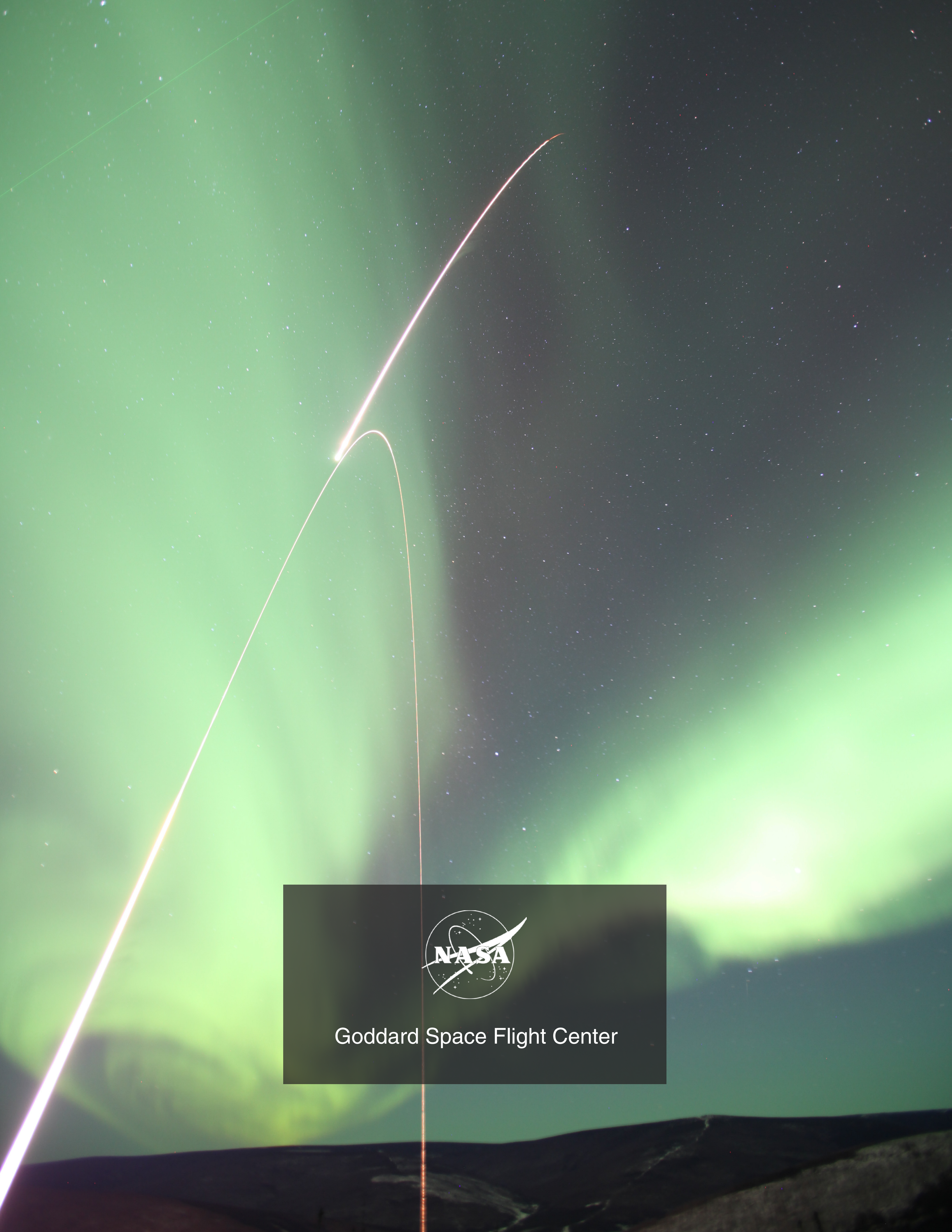
43 U.S.C. 1701, Federal Land Policy and Management Act of 1976.

U.S. Public Law

P.L. 90-542, Wild and Scenic Rivers Act.

P.L. 94-265, Magnuson-Stevens Fishery Conservation and Management Act.

P.L. 96-487, Alaska National Interest Lands Conservation Act.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