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.

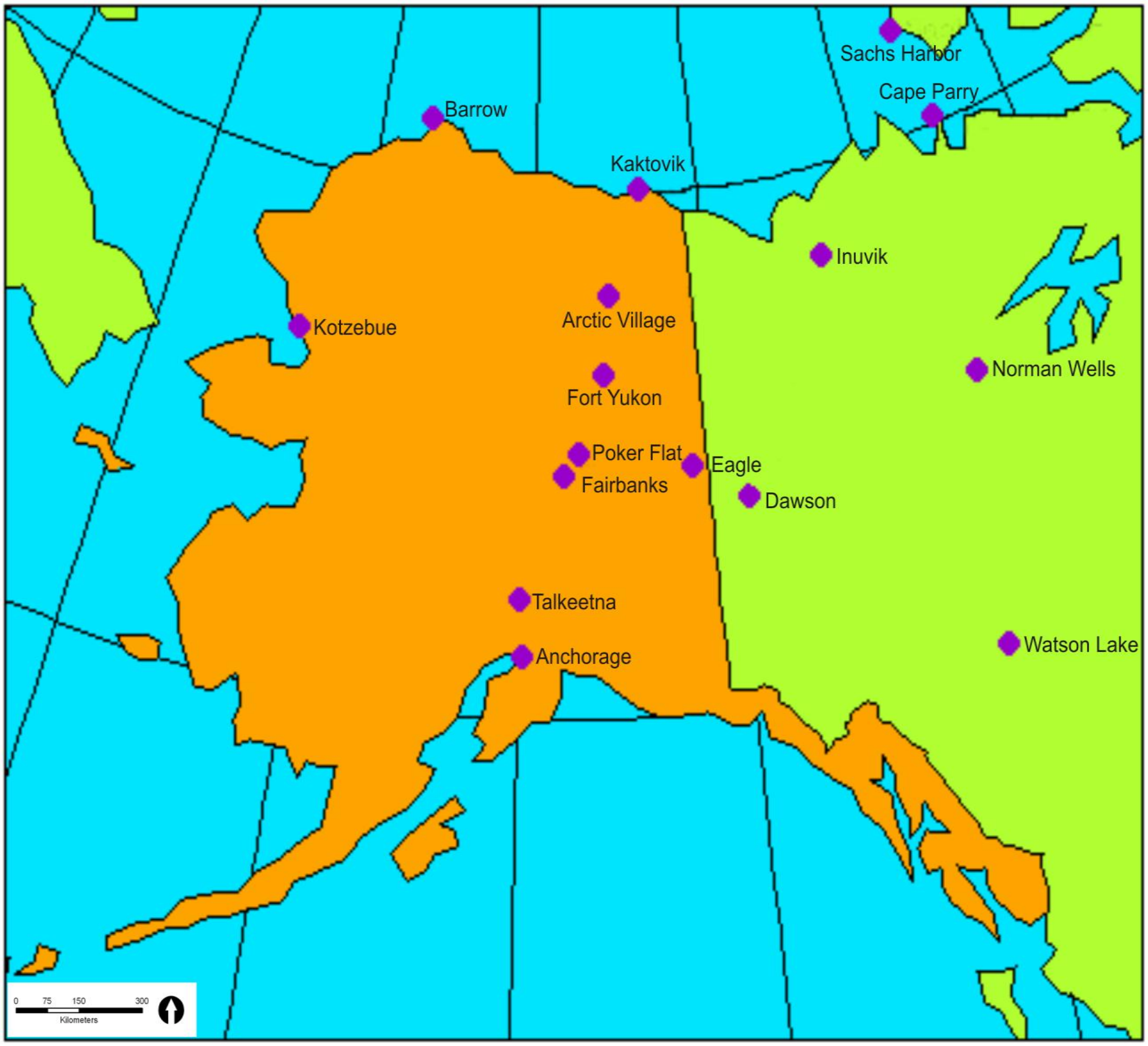


Figure 2–1. Poker Flat Research Range Vicinity Map

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.

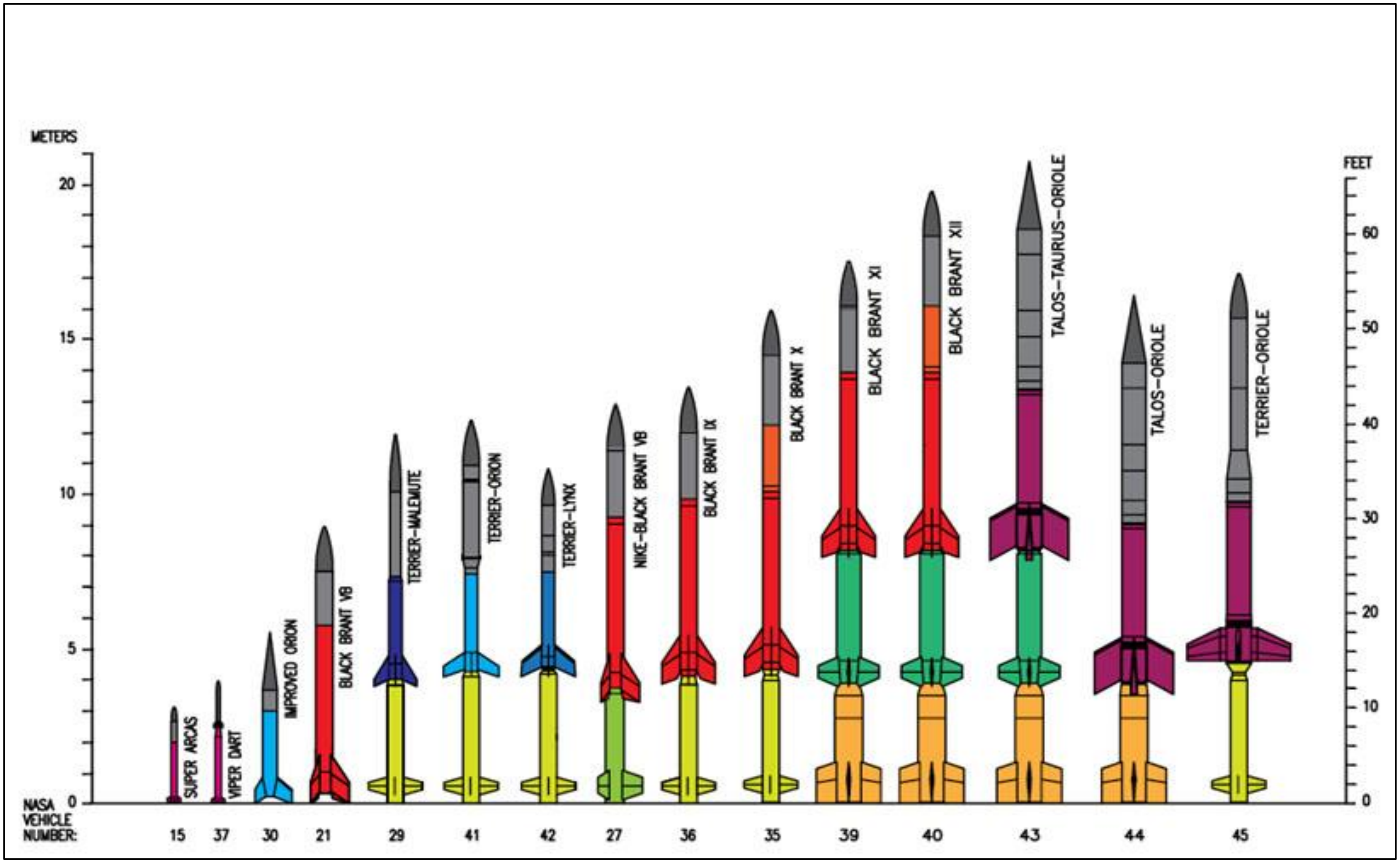


Figure 2–2. Representative Launch Vehicles, Ranging From a Single-Stage Orion to a Four-Stage Black Brant XII

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.

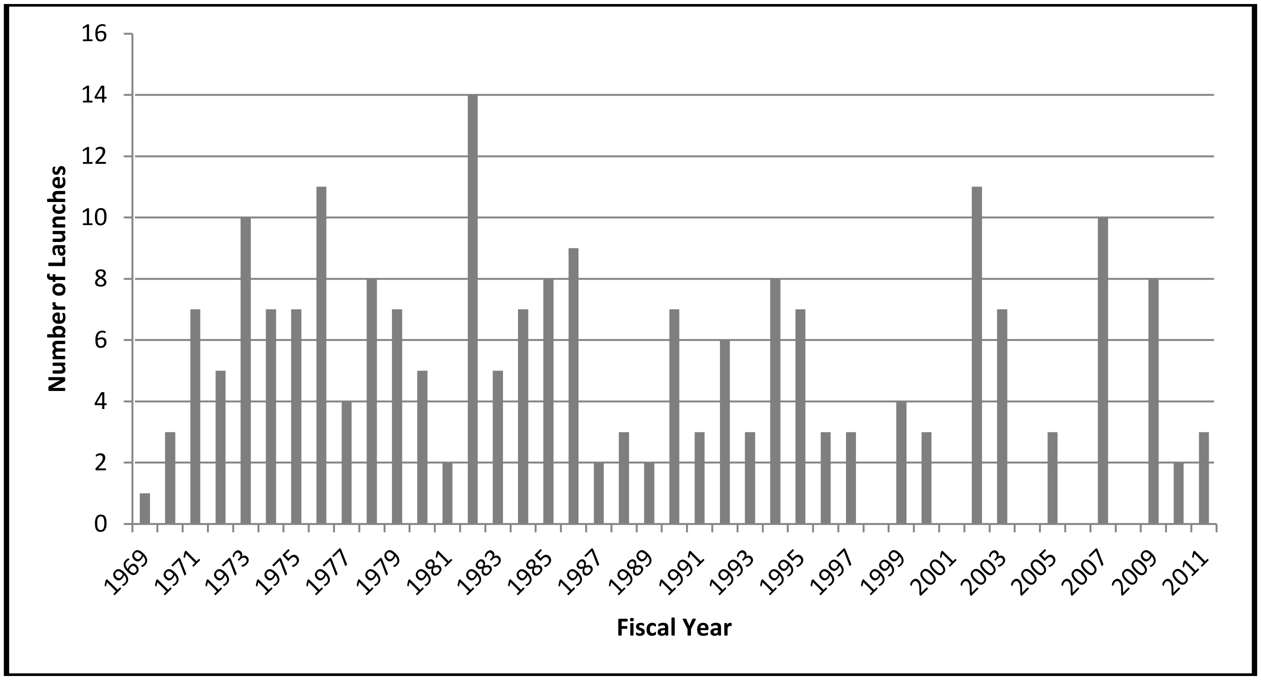


Figure 2–3. Sounding Rockets Launched by NASA from Poker Flat Research Range by Fiscal Year

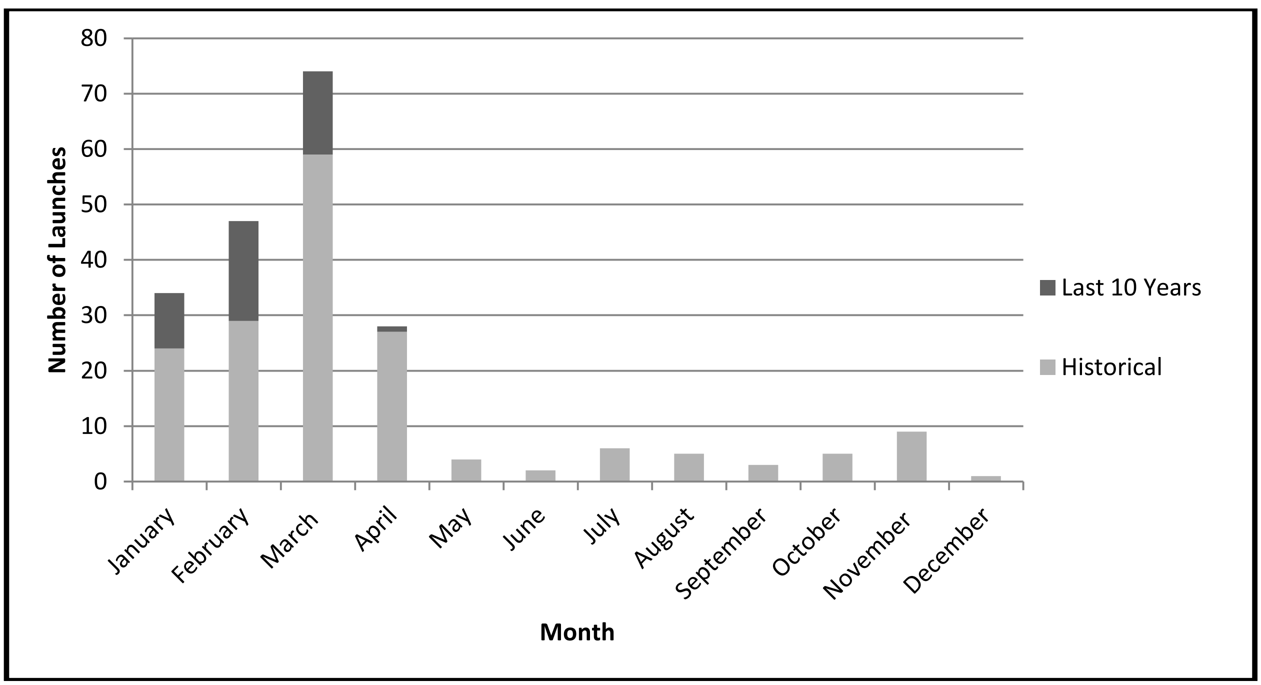


Figure 2–4. Numbers of Sounding Rocket Program Launches per Month

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**).

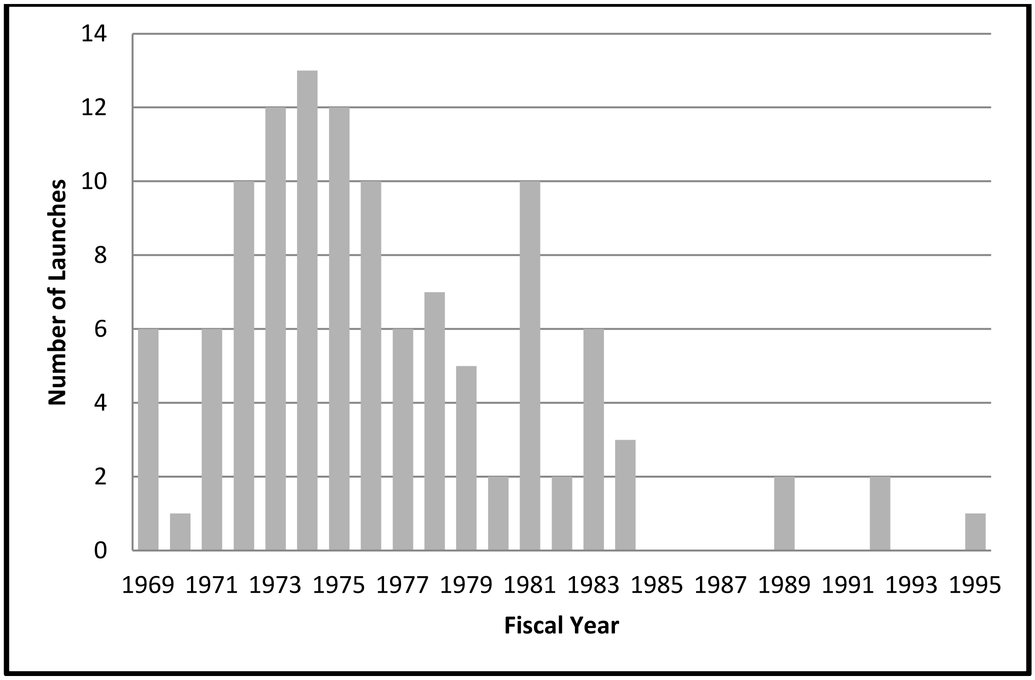


Figure 2–5. Non-NASA Sounding Rocket Launches from PFRR

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).

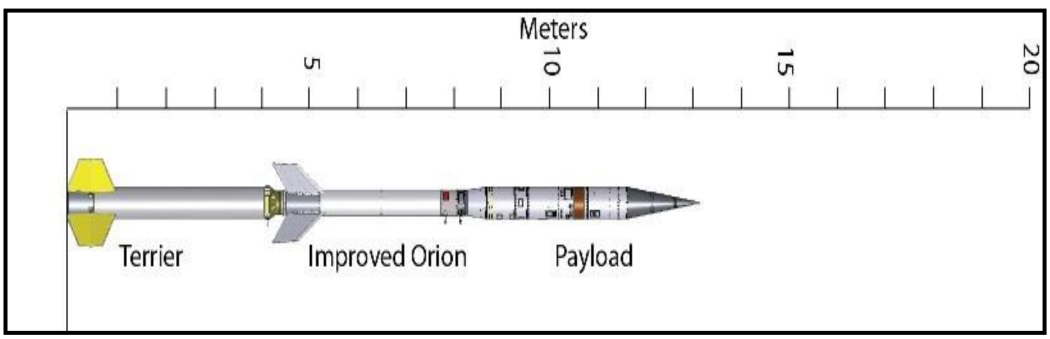


Figure 2–6. Terrier-Improved Orion Configuration

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).

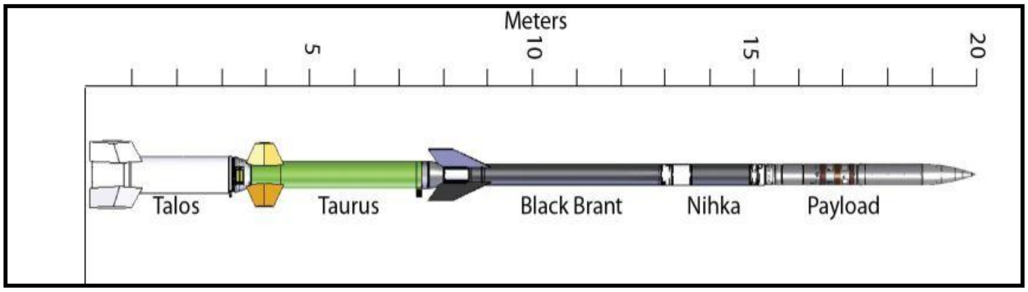


Figure 2–8. Black Brant XII Configuration

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**.

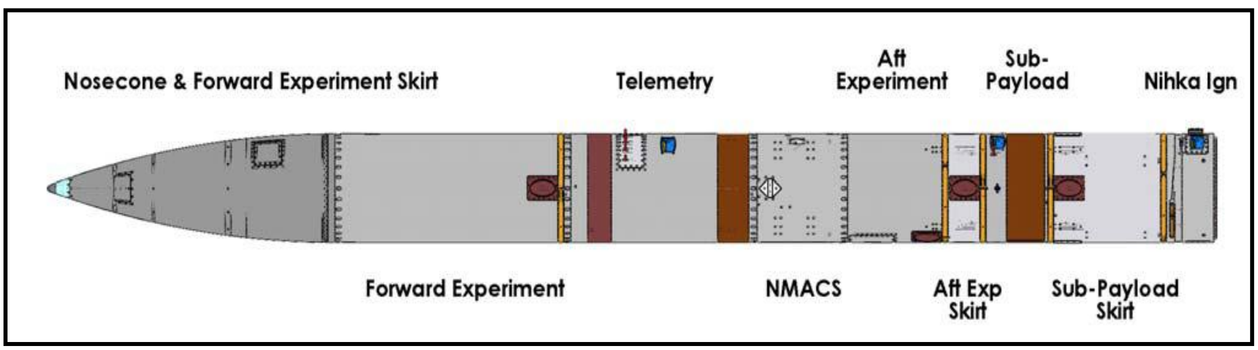


Figure 2–10. Typical Sounding Rockets Payload with Nose Cone

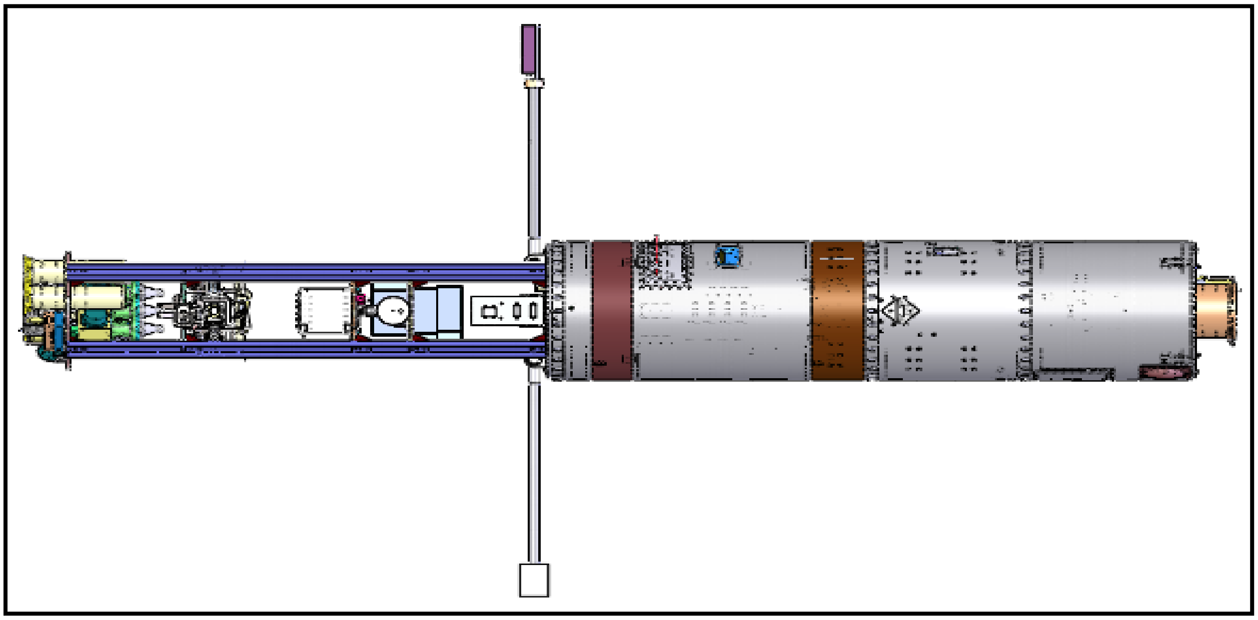


Figure 2–11. Typical Sounding Rockets Payload Without Nose Cone

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)**.

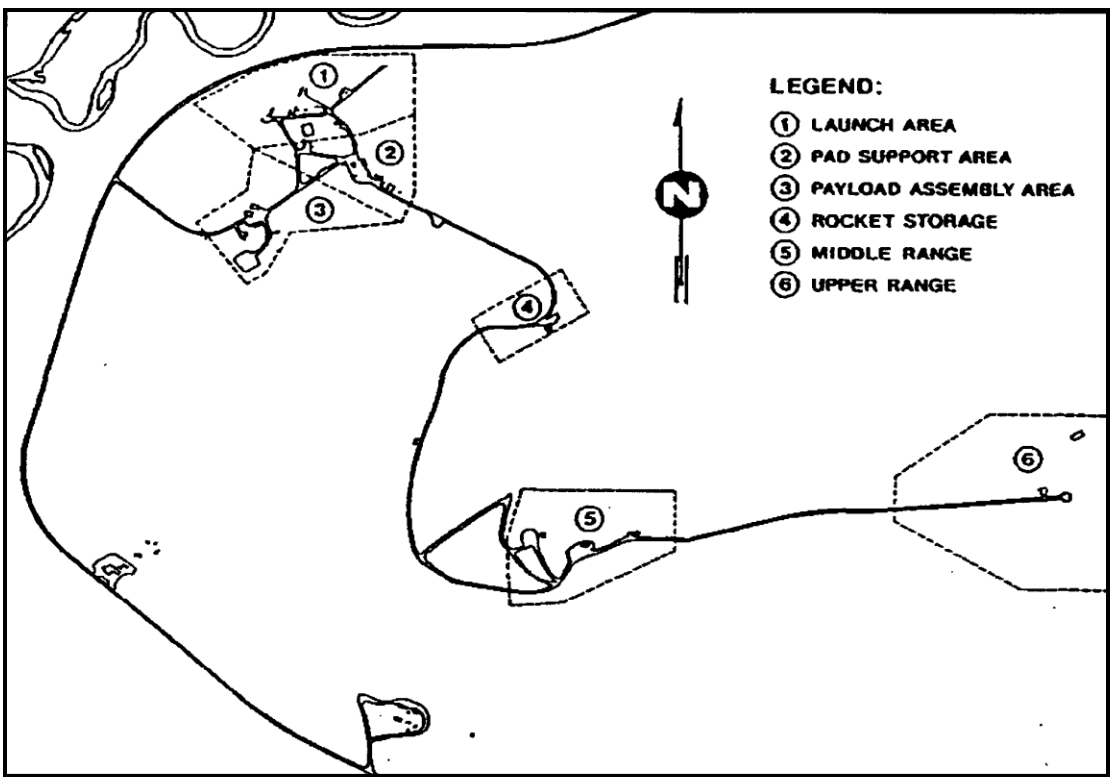


Figure 2–12. Poker Flat Research Range Areas

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)**.

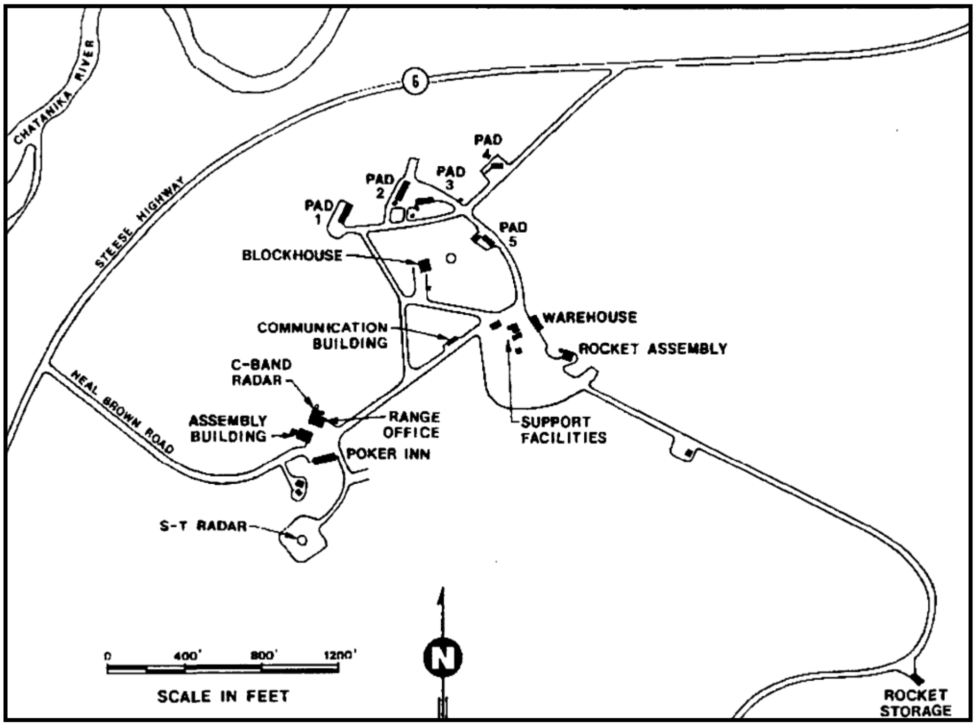


Figure 2–17. Poker Flat Research Range Launch Area Facilities

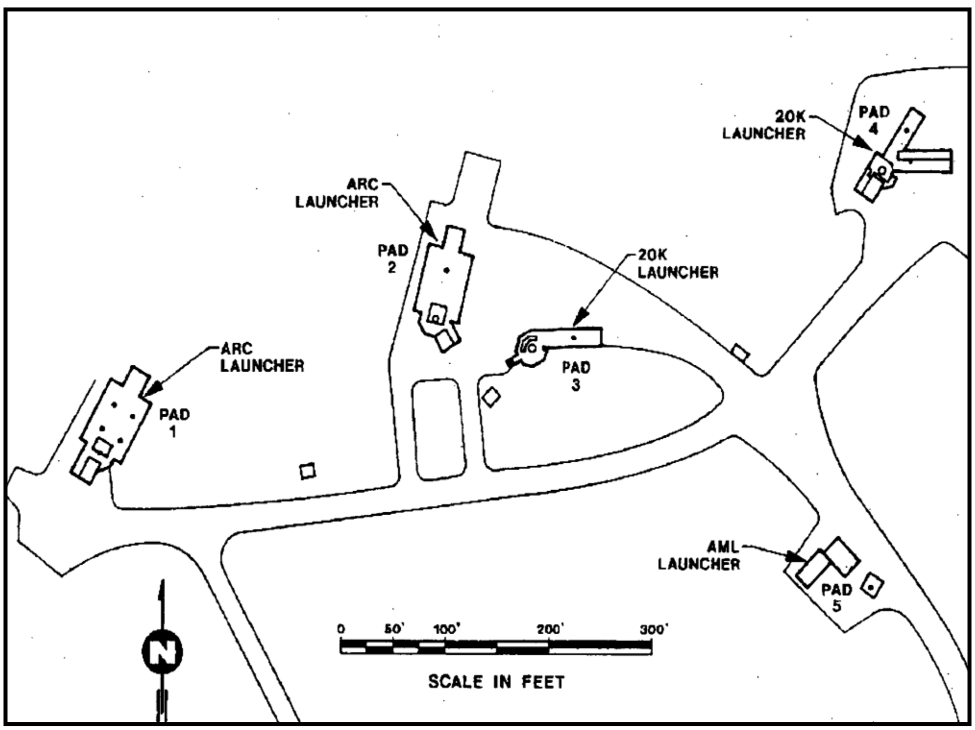


Figure 2–18. Poker Flat Research Range Launch Vicinity

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.

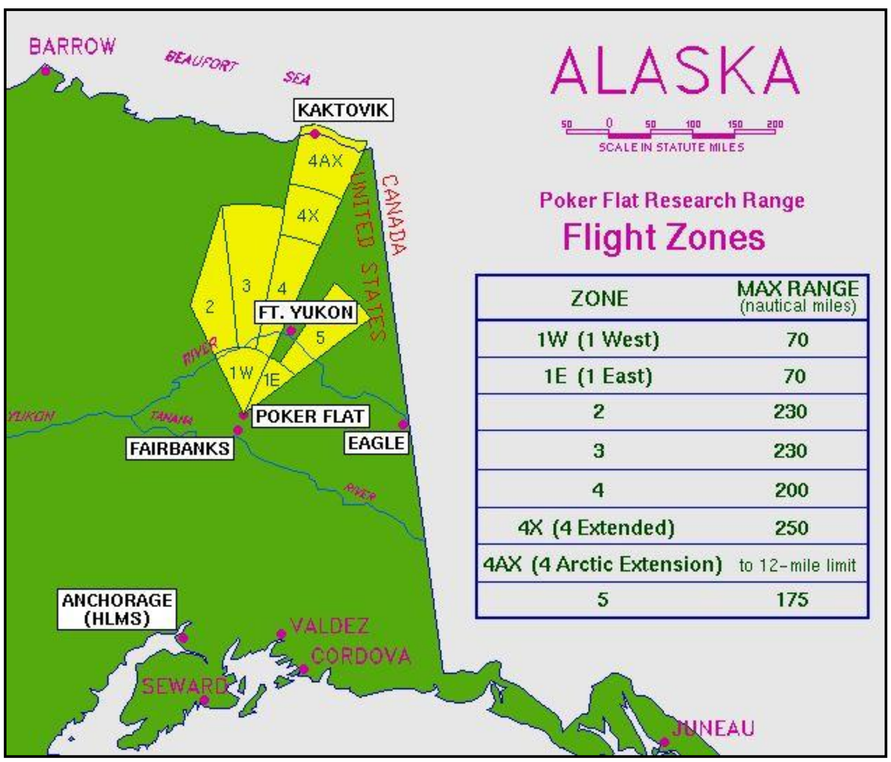
2.1.4 Downrange Support Facilities

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.

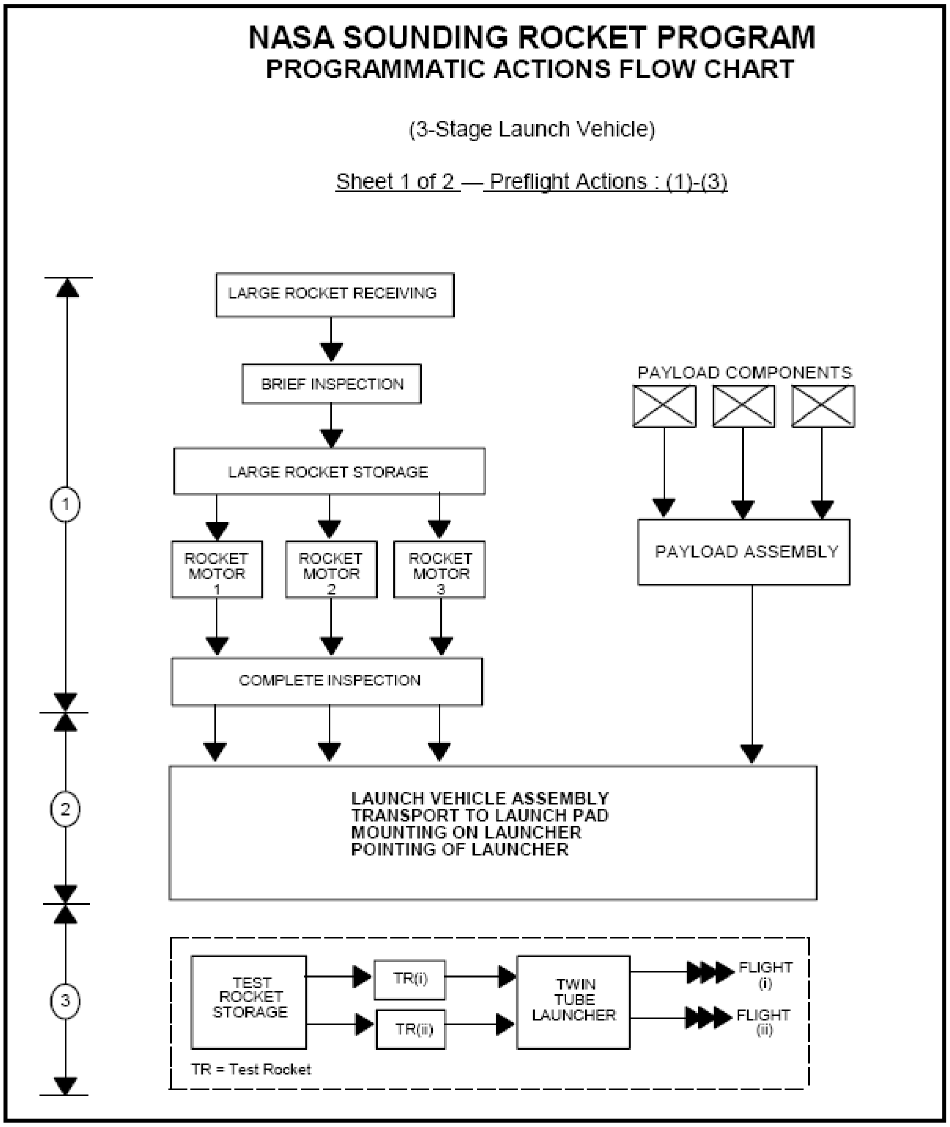


Figure 2–23. NASA Sounding Rockets Program Programmatic Actions Flow Chart, Sheet 1

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.

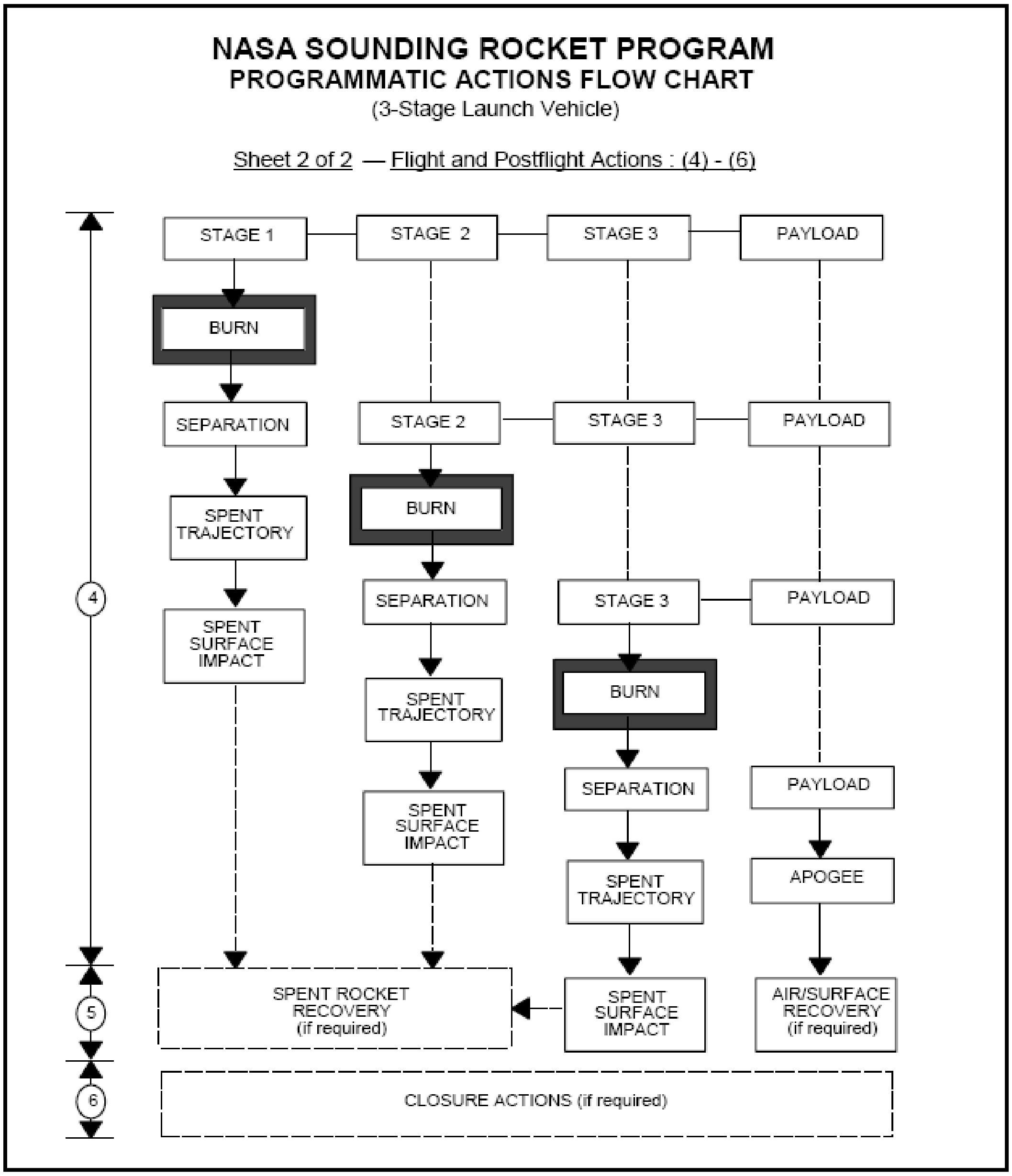


Figure 2–23. NASA Sounding Rockets Program Programmatic Actions Flow Chart, Sheet 2 (*continued*)

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*)

<table>
<tr><th>Date Reported</th><th>Type of Item</th><th>Reporter</th><th>Land Parcel</th><th>General Location</th><th>Date Recovered</th></tr>
<tr><td rowspan="6">August 2012</td><td>Payload</td><td>Commercial Air Operator</td><td>State of AK (west of Venetie Lands)</td><td>11 kilometers northeast of Brown Grass Lake</td><td>August 2012</td></tr>
<tr><td>Motor</td><td>PFRR Employee[c]</td><td>Arctic NWR</td><td rowspan="3">Near North Fork East Fork Chandalar River</td><td>August 2012</td></tr>
<tr><td>Nosecone</td><td>PFRR Employee[c]</td><td>Arctic NWR</td><td>August 2012</td></tr>
<tr><td>Payload</td><td>PFRR Employee[c]</td><td>Arctic NWR</td><td>August 2012</td></tr>
<tr><td>Motor</td><td>Private Citizen</td><td>Native Village of Venetie</td><td>Near Christian River</td><td>September 2012</td></tr>
<tr><td>Motor</td><td>Private Citizen</td><td>White Mountains NRA</td><td>Near Ophir Creek</td><td>September 2012</td></tr>
</table>

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.

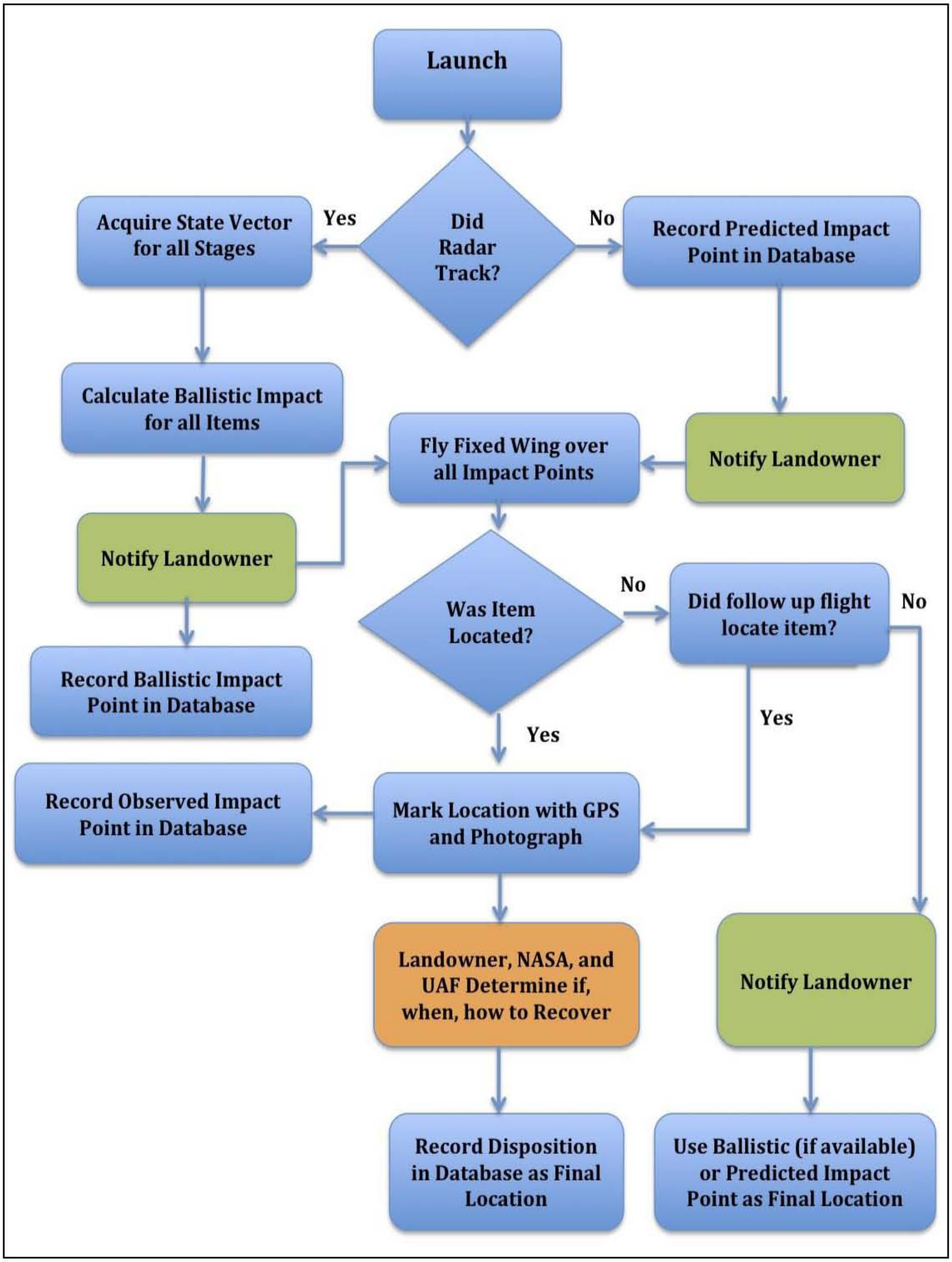
It is important to note that the focus of the recovery efforts under this tier is the downrange lands located north of the ADNR Poker Flat North and South Special Use property just across the Steese Highway from the PFRR launch site. Given the land use within the ADNR property (discussed in more detail 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.

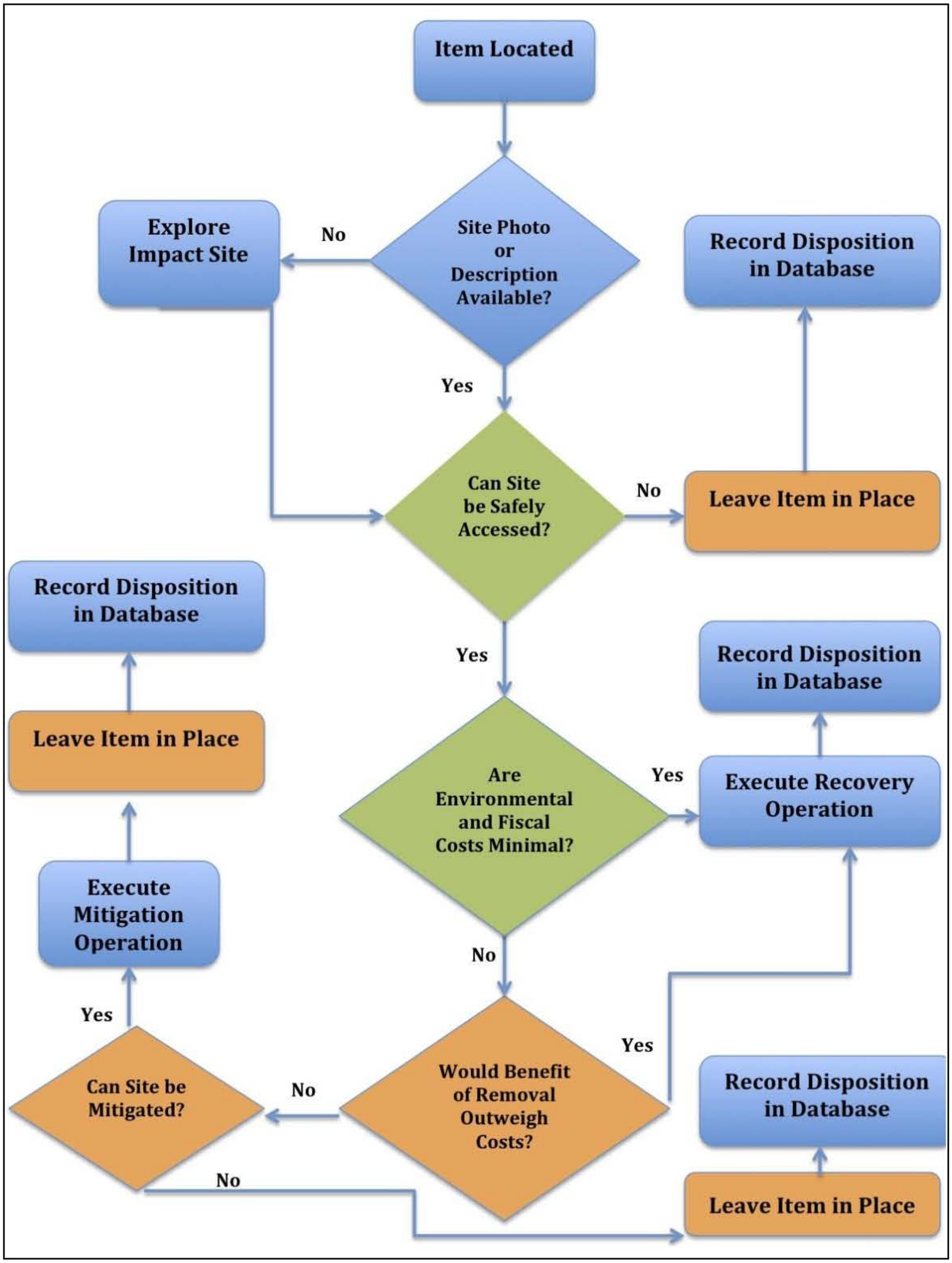
The following flow chart summarizes the decisionmaking process (see **Figure 2–37**), throughout which the landowner would be involved.

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.

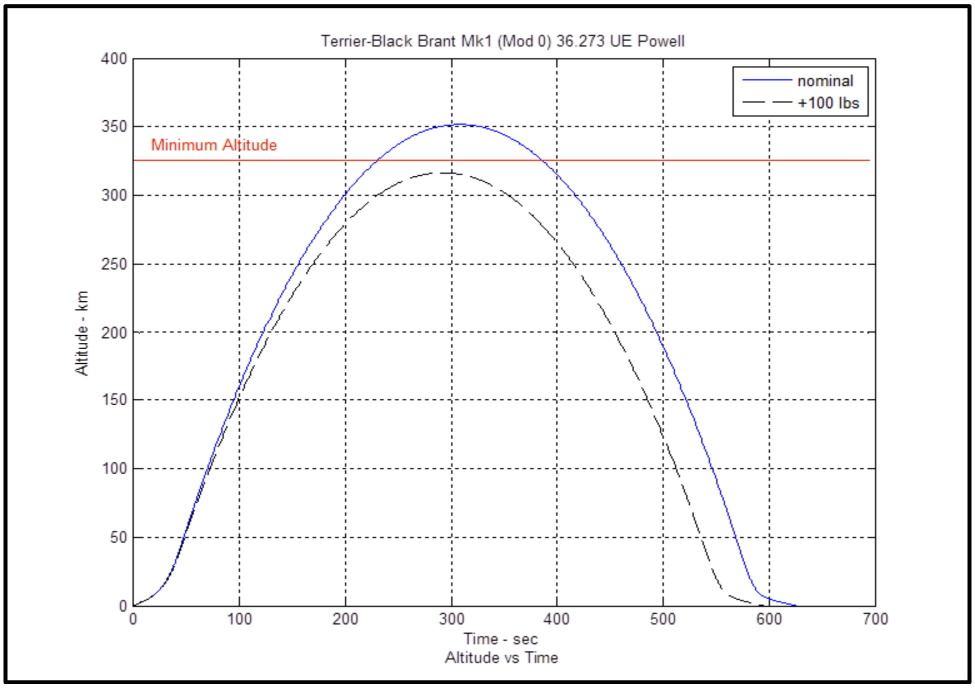


Figure 2–39. Effects of a Recovery System on a Recent Black Brant IX Trajectory

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.

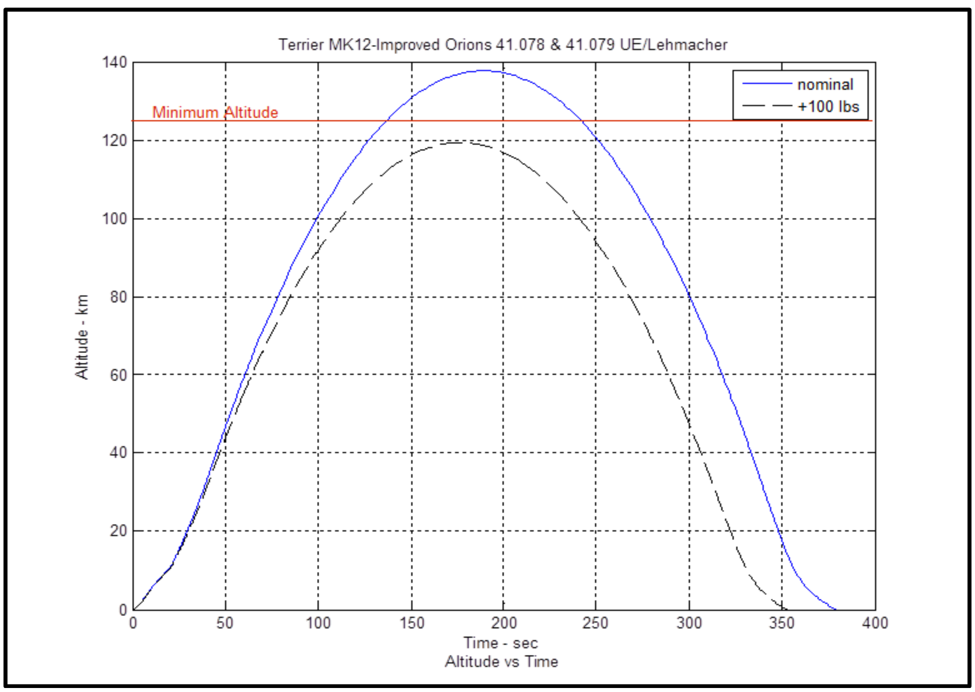


Figure 2–40. Effects of a Recovery System on a Recent Terrier-Improved Orion Trajectory

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.

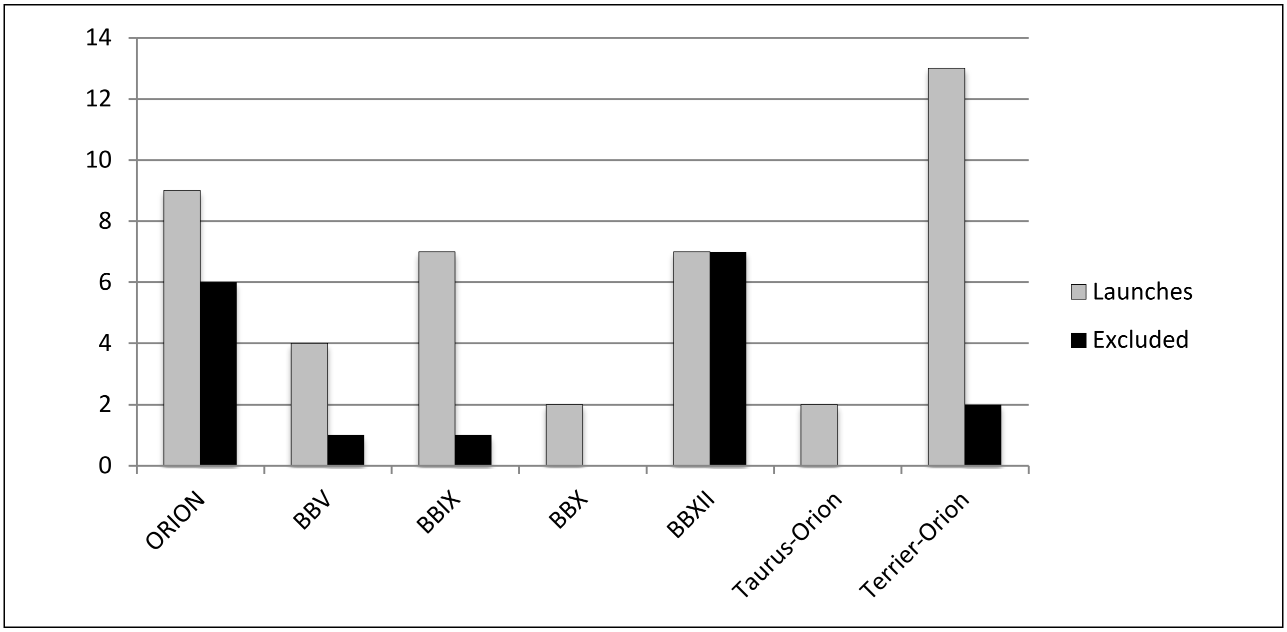


Figure 2–41. Effects of Adopting a 1:1,000 Risk Criterion for Wilderness Areas

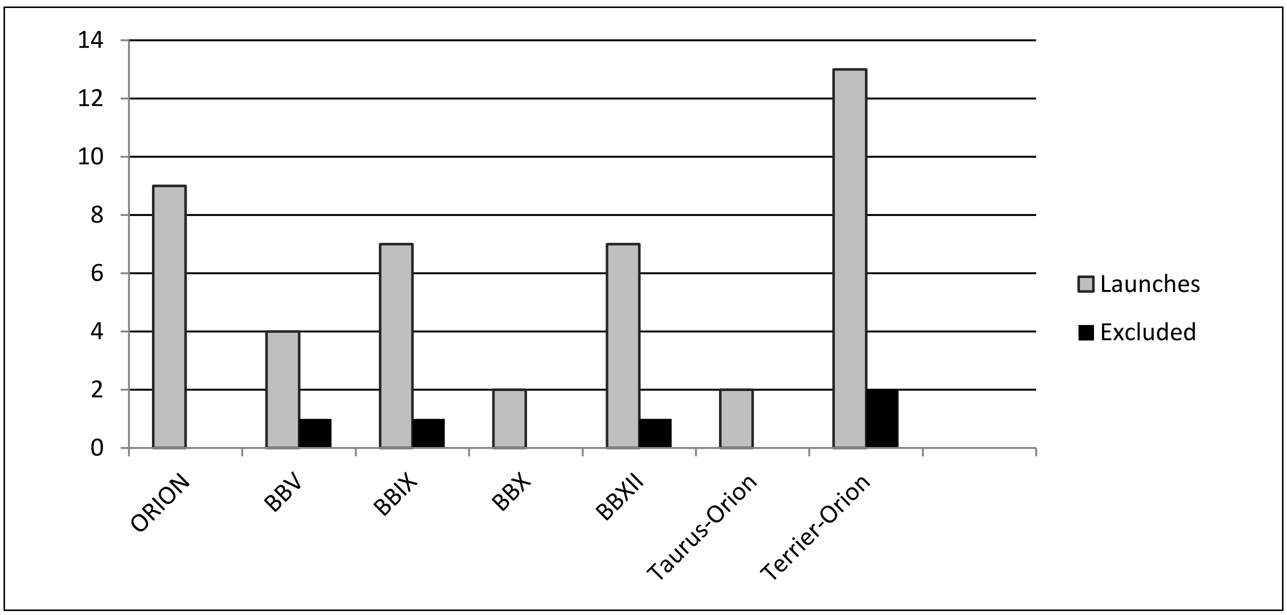


Figure 2–42. Effects of Adopting a 1:100 Risk Criterion for Wilderness Areas

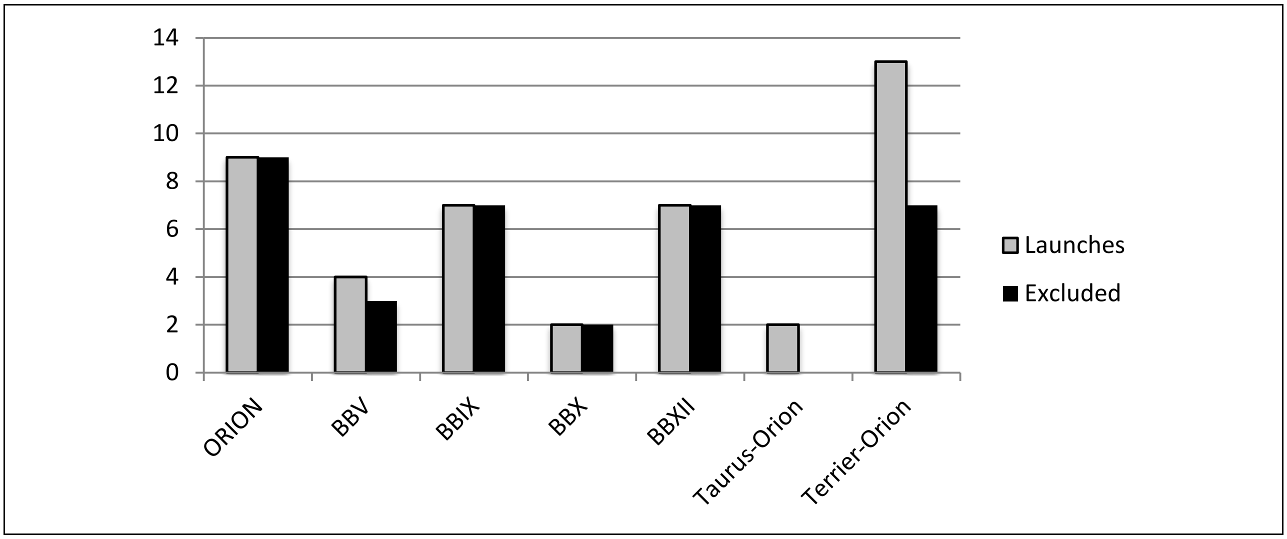


Figure 2–43. Effects of Adopting a 1:1,000 Risk Criterion for Wild River Corridors

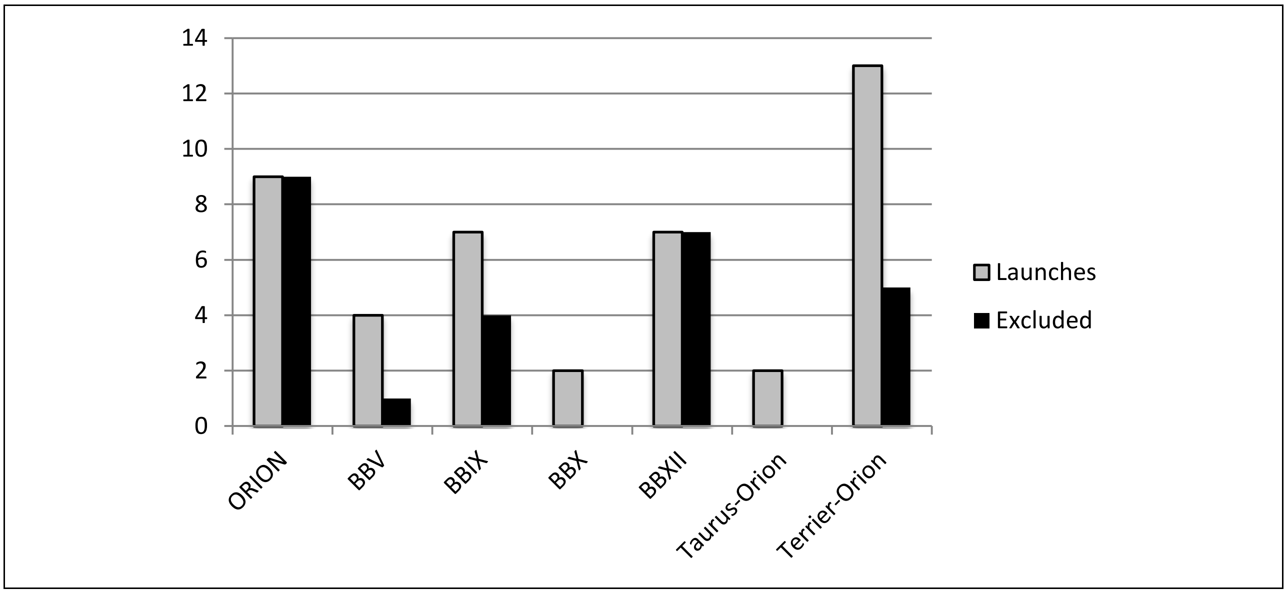


Figure 2–44. Effects of Adopting a 1:100 Risk Criterion for Wild River Corridors

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*	Rocket Launches – 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. Search and Recovery – 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.* 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
Water Resources	*No*	**Surface Water Quality:** Rocket Launches – 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.* Search and Recovery – 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*)		Search and Recovery – 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.* 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.				
Noise	*No*	Routine Operations – Routine PFRR activities, including the use of employee vehicles and delivery vehicles, would result in regional, adverse, long-term, and minor impacts. Rocket Launches – 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*)		Search and Recovery – 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*	PFRR Launch Site – No measurable changes to the appearance of the PFRR launch site would occur. Rocket Launches – 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. Search and Recovery – 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. <u>Summer Launches</u> – 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:** <u>Rocket Launches</u> – The ability of persons to visit or take part in recreational activities within downrange lands would not be restricted. <u>Search and Recovery</u> – 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*)		<u>Air Transport Incident Risk</u> – Approximately 1 chance in 4,800 years of air transport fatality. *Least impact of the Alternatives.* <u>Summer Launches</u> – 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*	<u>Rocket Launches</u> – 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.* Summer Launches – 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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