MOUNT RAINIER NATIONAL PARK WILDERNESS MINIMUM REQUIREMENTS WORKSHEET

Project Title: Mount Rainier Lahar Detection System Expansion
FINAL

MRDG Step 1: Determination

*Determine if Administrative Action is **Necessary***

Description of the Situation
What is the situation that may prompt administrative action?

The purpose of Mount Rainier National Park (park or MRNP) is to protect and preserve unimpaired the majestic icon of Mount Rainier, a glaciated volcano, along with its natural and cultural resources, values, and dynamic processes. The park provides opportunities for people to experience, understand, and care for the park environment, and also provides for wilderness experiences and sustains wilderness values.

Mount Rainier National Park protects more than 97 percent of its area as federally designated wilderness. As part of the Pacific Ring of Fire, Mount Rainier is an outstanding example of Cascade volcanism. Mount Rainier's eruptions and mudflows continue to shape the area and are a continuing threat to people both within and adjacent to designated wilderness. This includes park visitors, employees, and surrounding lowland communities, including the growing Seattle-Tacoma metropolitan area.

The uniquely rugged and dynamic nature of the landscape in MRNP is among the most beautiful in the National Park System. However, that same landscape also produces some of the greatest measurable hazards in North America. Mount Rainier has experienced episodic volcanic activity throughout its approximately 500,000-year history. Geologists have found evidence for a number of eruptions over the last 6,000 years, most recently 1,000 years before present. They have also found evidence for at least eight large lahars (or volcanic mudflows) produced by eruptions at the summit that reached into areas of the Puget Lowlands that today are populated by thousands of people. In addition, a ninth large lahar (the "Electron Mudflow") that occurred around 1500 A.D. and reached into areas now occupied by Orting and Sumner was initiated by a landslide, not an eruption.

Recent geologic and geophysical studies have found evidence of weak rock on the western flank around Sunset Amphitheater of Mount Rainier, suggesting that a future landslide-caused lahar down the Puyallup or Nisqually River is a potential hazard that needs to be considered in addition to hazards associated with lahars that may be triggered by future eruptions of the volcano. Since the onset of landslides is inherently unpredictable, it is conceivable that a collapse-driven lahar like the Electron Mudflow could occur with little or no warning. In such an event, recent modeling indicates that a large lahar could reach Orting within 60 minutes along the Puyallup River, the Nisqually entrance to MRNP within 10 minutes, and parts of Ashford within 20 minutes.

In addition to the volcanic and landslide-generated lahars, lahars and smaller debris flows can be generated hydrologically. Mount Rainier has been observed to produce debris flows as a result of glacial outburst floods or heavy rain events. Debris flows range in size and destructive potential, with minor flows occurring as frequently as annually, and larger destructive flows predicted to occur every 100 to 200 years.

The geographic extent of these potentially destructive natural phenomenon ranges from local (within the wilderness area) to regional. The largest potential loss of life is associated with an edifice-collapse lahar similar to the Electron Mudflow. Hydrologically generated debris flows are less likely to threaten population centers, but have the potential to reach populated park areas, including wilderness and front-country campsites, park roads, and the Longmire and Kautz Creek administrative areas within 10 to 20 minutes. The amount of time wilderness users would have to react to an event depends greatly on location within the affected drainage and would generally be less than 10 minutes.

In each of these scenarios, the principal mitigation strategy is to have a lahar detection system in place that can provide alerts to emergency managers and park personnel to provide as much time as possible for potentially affected populations to evacuate to high ground before a lahar arrives and to inform emergency response needs. To provide reliable early warning in the event of future volcanic unrest and eruption, the United States Geological Survey (USGS) issued a recommendation in 2008 that Very High Threat volcanoes should have 12 to 20 seismic and Global Positioning System (GPS) stations located within 20 kilometers of the summit. The actual number of required stations within that broad range depends on many factors that are specific to each volcano, especially the size of the volcano. For example, to achieve the same capabilities at Mount Rainier as at Mount St. Helens, more stations would be required because Mount Rainier is a larger volcano. In addition to the need to improve the volcano monitoring capabilities of the Mount Rainier volcano monitoring network, the capability to rapidly detect debris flows and lahars without producing false alarms is needed so that authorities inside and outside the park have as much time to act as possible to get people out of harm’s way. Management actions could include emergency phone alerts, activation of warning sirens, door-to-door evacuations, road closures, suspension of wilderness permits, preemptive evacuation of park visitors and staff from backcountry and wilderness areas of the park, and search and rescue response.

As of December 2020, the Mount Rainier network of monitoring stations consists of 18 seismic and 6 GPS installations located within 20 kilometers (12 miles) of the summit, including 13 seismic and 6 GPS sites inside the park (some seismic and GPS stations are collocated; there are 15 total volcano monitoring sites in MRNP). Five of these sites are in designated wilderness. The current network has been sited and equipped to monitor unrest associated with a volcanic eruption and detect large lahars on several major drainages at points near the park boundaries (more detail on the drainages can be found in the EA, page 4). However, real-time information that would be critical for early detection and tracking of lahars and debris flows, including which drainages are affected, the volume of material, how fast it is moving, how far it will go downstream, and how soon it might reach residential areas, is not available from the existing network, nor is the ability to detect a spontaneous collapse-driven lahar in the higher risk area of weak rock on the western flank around Sunset Amphitheater of Mount Rainier.

Lastly, Mount Rainier is the most heavily glaciated peak in the lower 48 states and presents an unparalleled natural laboratory for the study of volcanic and glacial processes. The geologically dynamic nature of the peak is an inherent element of the scenic and natural grandeur that led to the establishment of the national park. The unique geologic and volcanic features and processes contribute to the park's wilderness character to the extent that they occur naturally and unimpeded by man. President Gerald Ford, in his 1974 message to Congress proposing the establishment of the Mount Rainier Wilderness, specifically referred to the "ice-clad, dormant volcano" as a primary feature of the wilderness. In addition, the 1974 Wilderness Proposal Environmental Impact Statement included a recommendation that a special provision be included in the wilderness legislation to permit the continued use of mechanical instrumentation in the wilderness, including the use of helicopters, in connection with volcanic and glacier research. This special provision was not ultimately included in the wilderness legislation, presumably because such activities could be considered through the minimum requirement analysis process.

As glaciers recede, unpredictable events such as glacial outburst floods may become more frequent in all park drainages. As stated above, such events threaten park infrastructure, including roads, wilderness trails, bridges, campgrounds, administrative areas, and other facilities, and pose a hazard to park visitors, including visitors to the Mount Rainier wilderness. Little is known about the initiation and propagation of these smaller events, but they are a key consideration in planning for sustainable visitor access to the park, its facilities, and recreational opportunities in wilderness. There is an unparalleled opportunity for study and understanding of these unique geologic features of value, with benefits to public appreciation for these features as well as applications around the world, wherever similar geologic and volcanic features threaten wilderness users, recreation access, and downstream communities.

Options Outside of Wilderness
Can action be taken outside of wilderness that adequately addresses the situation?

☐ YES **STOP – DO NOT TAKE ACTION IN WILDERNESS**

☒ NO **EXPLAIN AND COMPLETE STEP 1 OF THE MRDG**

Explain:
The existing volcano monitoring network includes many stations outside of wilderness. For example, lahar detection stations for the Puyallup River drainage are sited entirely outside of the Mount Rainier Wilderness and can provide adequate warning for the nearest downstream communities. However, for the Tahoma Creek, Kautz Creek, or Nisqually River, the existing monitoring network would be unable to detect lahar events until several minutes after they initiate, and the impacted drainage would be more difficult to discern in a timely manner, meaning that events would impact wilderness and adjacent use areas in the park with effectively no warning, and the warning time would be delayed for areas outside the park.

The improvements to lahar detection necessary for emergency managers to notify or initiate evacuation of visitors and staff inside the wilderness or other areas of the park, as well as for residential areas near the park entrance, could not be gained by adding more monitoring stations outside of wilderness. In particular, infrasound instruments, which have been shown to be effective in detecting subaudible sound waves created by moving surface flows such as debris flows and lahars, can be significantly disrupted by topography, so multiple stations within each drainage are needed for reliable detection. Real-time data from stations is sent by digital radio signal, which requires line-of-sight to radio repeaters on high points around the drainages of interest. Most of these high points are within designated wilderness at Mount Rainier.

Criteria for Determining Necessity
Is action necessary to meet any of the criteria below?

A. Valid Existing Rights or Special Provisions of Wilderness Legislation

*Is action necessary to satisfy valid existing rights or a special provision in wilderness legislation (the Wilderness Act of 1964 or subsequent wilderness laws) that **requires** action? Cite law and section.*

☐ YES ☒ NO

B. Requirements of Other Legislation

*Is action necessary to meet the requirements of **other federal laws**? Cite law and section.*

☒ YES ☐ NO

Explain:

John D. Dingell, Jr. Conservation, Management, and Recreation Act of 2019, Title V-Hazards and Mapping, Section 5001. National Volcano Early Warning and Monitoring System (Dingell Act).

This legislation directs the USGS to establish a national volcano early warning and monitoring system. The legislation states that Secretary of the Interior "shall establish within the United States Geological Survey a system, to be known as the National Volcano Early Warning and Monitoring System, to monitor, warn, and protect citizens of the United States from undue and avoidable harm from volcanic activity." The purposes of the volcanic monitoring system are to organize, modernize, standardize, and stabilize the monitoring systems of the volcano observatories in the United States, including the Cascades Volcano Observatory; and to unify the monitoring systems of volcano observatories in the United States into a single interoperative system.

The objective of the system is to monitor all the volcanoes in the United States at a level commensurate with the threat posed by the volcanoes by (1) upgrading existing networks on monitored volcanoes, (2) installing new networks on unmonitored volcanoes, and (3) employing geodetic and other components. Modernization activities under the system shall include the comprehensive application of emerging technologies, including digital broadband seismometers, real-time continuous GPS receivers, satellite and airborne radar interferometry, acoustic pressure sensors, and spectrometry to measure gas emissions.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act)

The Stafford Act is a 1988 amended version of the Disaster Relief Act of 1974. Section 202(a) states that "the President shall insure that all appropriate Federal agencies are prepared to issue warnings of disasters to State and local officials." In addition, Section 202(b) states that "the President shall direct appropriate Federal agencies to provide technical assistance to State and local governments to insure that timely and effective disaster warning is provided." The director of the USGS, through the Secretary of the Interior, has been delegated the responsibility to issue disaster warnings "for an earthquake, volcanic eruption, landslide, or other geologic catastrophe."

Earthquake Hazards Reduction Act of 1977

The Earthquake Hazards Reduction Act of 1977 sets as a national goal the reduction in the risks of life and property from future earthquakes in the United States through the establishment and maintenance of a balanced earthquake program encompassing prediction and hazard assessment research, seismic monitoring, and information dissemination. P.L. 101-614 reauthorizes the act.

The National Park Service Organic Act

The National Park Service Organic Act established a statutory mandate to "*conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*"

C. Wilderness Character

Is action necessary to preserve one or more of the five qualities of wilderness character?

UNTRAMMELED

☐ YES ☒ NO

UNDEVELOPED

☐ YES ☒ NO

NATURAL

☐ YES ☒ NO

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

☐ YES ☒ NO

OTHER FEATURES OF VALUE

☒ YES ☐ NO

Mount Rainier is a living laboratory that offers opportunities for scientists and students to study and develop a deeper understanding of, as well as foster an appreciation for, the park, its resources, processes, and meanings. The dynamic volcanic and glacial features of Mount Rainier have been identified as features of geologic value in the wilderness in the park's Wilderness Character Narrative (NPS 2017).

Improved understanding of the initiation and propagation of processes such as glacial outburst floods and debris flows has the potential to benefit scientific understanding, education, and public appreciation for these features of the Mount Rainier Wilderness. Because Mount Rainier is uniquely valuable as a natural laboratory for study of these processes, and the frequency and extent of these natural events are expected to change as glaciers recede, valuable knowledge would be lost if no action is taken.

The USGS monitoring program would provide scientific information that deepens knowledge and understanding of the Mount Rainier volcano and wilderness and would inform public safety and access to recreational opportunities in the Mount Rainier Wilderness and adjacent areas, fulfilling the "scientific" and "educational" public purposes of wilderness areas established in Section 4(b) of the Wilderness Act.

Step 1 Determination
*Is administrative action **necessary** in wilderness?*

Is administrative action **necessary** in wilderness?

☒ YES **EXPLAIN AND COMPLETE STEP 1 OF THE MRDG**

☐ NO **STOP – DO NOT TAKE ACTION IN WILDERNESS**

Explain:
(1) Action is necessary under the Dingell Act, Stafford Act, Earthquake Hazards Reduction Act, and the NPS Organic Act for public safety purposes.

These laws, and the Dingell Act in particular, mandate the USGS to expand and modernize the existing volcanic monitoring network at Mount Rainier to provide for public safety. The Dingell Act requires that USGS establish the National Volcano Early Warning and Monitoring System "to monitor, warn, and protect citizens of the United States from undue and avoidable harm from volcanic activity," in part by upgrading existing networks on monitored volcanoes such as Mount Rainier, by including comprehensive application of emerging technologies. While the Dingell Act does not explicitly require additional installations in wilderness, the hazards are initiated in wilderness, have the potential to impact wilderness users as well as communities immediately adjacent to wilderness boundaries, and cannot be adequately detected from locations outside the wilderness. Therefore, to effectively accomplish the legislated mission of implementing and upgrading a volcanic early warning system, some action must be taken in wilderness.

To fulfill this statutory mandate, the USGS is proposing a substantial upgrade to the present-day volcano monitoring network at Mount Rainier to improve the capability to detect unrest leading to an eruption (following the standards put forward in the National Volcanic Early Warning System (NVEWS), pursuant to Title II of the Stafford Act) and would enable the capability to detect a large lahar within minutes of initiation, with particular focus on a landslide-generated lahar down the Puyallup River and Tahoma Creek drainages. The USGS proposes to install modern monitoring stations that consist of multiple types of sensors in order to provide early detection capabilities of surface events such as lahars, debris flows, and outburst floods.

If the proposed stations are not installed, the existing monitoring network would be unable to provide confirmation that a lahar has been generated along Tahoma Creek, and lahar detection along the Puyallup River would be delayed by 5 to 10 minutes (or more), until the lahar reached the existing lahar detection system operated by the USGS outside of the park. This would mean

that events would impact wilderness and adjacent use areas in the park with effectively no warning, and the warning time would be reduced for areas outside the park. Prioritizing the rapid detection of such events is intended to enable the NPS and USGS to provide warning to areas of impact and initiate a response to the events as they are happening.

The lahar detection system also fulfills the park's mandate under the NPS Organic Act, as implemented by NPS Management Policies. The Wilderness Act Section 4(a)(3) provides that nothing in the Wilderness Act "shall modify the statutory authority under which the units of the national park system are created" and that wilderness designation "shall in no manner lower the standards evolved for the use and preservation of such park, monument, or other unit of the national park system…" NPS Management Policies Section 4.8.1.3 states that "the Service will work closely with specialists at the U.S. Geological Survey and elsewhere, and with local, state, tribal, and federal disaster management officials, to devise effective geologic hazard identification and management strategies" and "minimize their potential impact on visitors, staff, and developed areas." The detection system would further the park's ability to identity geologic hazards and minimize their potential impacts on visitors, staff, and developed areas by issuing as early warning as possible to save lives through evacuation or sheltering to the greatest extent possible.

(2) Action is also necessary because it benefits certain aspects of wilderness character, including scientific values and public purposes.

The action would contribute to the "other features of scientific, educational, scenic, or historical value" quality of wilderness character and furthers the public purposes of scientific and educational use (16 United States Code (USC) §§ 1131(c); 1133(b)). Mount Rainier National Park offers an excellent natural laboratory to further scientific understanding of debris flows. Recordings of debris flows are important to the broader scientific community, as recordings of such flows on multiple high-quality stations are relatively rare and would help develop understanding of their initiation and dynamics. The proposed network would also provide a long-term backbone for denser temporary deployments of instrumentation that would provide even higher-fidelity datasets that are critical for informing models of debris flow generation and movement. Such models would ultimately lead to an improved ability to detect and characterize debris flows on Mount Rainier as well as other places around the world, and would enable the park to better inform visitors, including wilderness users, of local hazards and how the park itself handles such events.

Additional benefits that cannot yet be quantified are likely to result from the installation of the system, including enhancing our detection ability and understanding of rockfall, glacial dynamics, flooding, and potentially more. The proposed stations would also improve volcano monitoring capabilities, including the ability to detect anomalous small earthquakes and ground deformation that often precede eruptions, and to detect explosions that often accompany volcanic unrest and eruption. Finally, data collected using stations in the proposed network would also be useful in detecting smaller debris flows and outburst floods in Tahoma Creek and elsewhere in the park, which is important for both situational awareness and hazard mitigation in

the park. The Tahoma Creek drainage itself has experienced more than 33 debris flows since 1967.

These benefits to wilderness character must be weighed against the impacts on the undeveloped quality of wilderness character. Impacts will be minimized to the extent possible while still fulfilling statutory direction, including the Dingell Act, as discussed in Step 2.

MRDG Step 2

*Determine the **Minimum** Activity*

Other Direction

*Is there "special provisions" language in legislation (or other Congressional direction) that explicitly **allows** consideration of a use otherwise prohibited by Section 4(c)?*

AND/OR

Has the issue been addressed in agency policy, management plans, species recovery plans, or agreements with other agencies or partners?

☒ YES **DESCRIBE OTHER DIRECTION**

☐ NO **SKIP AHEAD TO TIME CONSTRAINTS BELOW**

Describe Other Direction:

2006 NPS Management Policies

4.8.1.3 Geologic Hazards: "Naturally occurring geologic processes, which the Park Service is charged to preserve unimpaired, can be hazardous to humans and park infrastructure. These include earthquakes, volcanic eruptions, mudflows, landslides, floods, shoreline processes, tsunamis, and avalanches. The Service will work closely with specialists at the U.S. Geological Survey and elsewhere, and with local, state, tribal, and federal disaster management officials, to devise effective geologic hazard identification and management strategies. Although the magnitude and timing of future geologic hazards are difficult to forecast, park managers will strive to understand future hazards and, once the hazards are understood, minimize their potential impact on visitors, staff, and developed areas."

Section 6.3.6, Scientific Activities in Wilderness: "Scientific activities are to be encouraged in wilderness. Even those scientific activities (including inventory, monitoring, and research) that involve a potential impact to wilderness resources or values (including access, ground disturbance, use of equipment, and animal welfare) should be allowed when the benefits of what can be learned outweigh the impacts on wilderness resources or values. However, all such activities must also be evaluated using the minimum requirement concept and include documented compliance that assesses impacts against benefits to wilderness. This process should ensure that the activity is appropriate and uses the minimum tool required to accomplish project objectives. Scientific activities involving prohibitions identified in Section 4(c) of the Wilderness Act (16 USC 1133(c)) may be conducted within wilderness when the following occur:

- The desired information is essential for understanding the health, management, or administration of wilderness, and the project cannot be reasonably modified to eliminate or reduce the nonconforming wilderness use(s); or if it increases scientific knowledge,

even when this serves no immediate wilderness management purposes, provided it does not compromise wilderness resources or character. The preservation of wilderness resources and character will be given significantly more weight than economic efficiency and/or convenience.

- Compliance with the National Environmental Policy Act (including completion of documented categorical exclusions, environmental assessments/findings of no significant impact, or environmental impact statements/records of decision) and other regulatory compliance (including compliance with Section 106 of the National Historic Preservation Act (16 USC 470(f)) are accomplished and documented.

- All scientific activities will be accomplished in accordance with terms and conditions adopted at the time the research permit is approved. Later requests for exceptions to the Wilderness Act will require additional review and approval.

- The project will not significantly interfere with other wilderness purposes (recreational, scenic, educational, conservation, or historical) over a broad area or for a long period of time.

- The minimum requirement concept is applied to implementation of the project.

Research and monitoring devices (e.g., video cameras, data loggers, meteorological stations) may be installed and operated in wilderness if (1) the desired information is essential for the administration and preservation of wilderness and cannot be obtained from a location outside wilderness without significant loss of precision and applicability; and (2) the proposed device is the minimum requirement necessary to accomplish the research objective safely.

Park managers will work with researchers to make NPS wilderness area research a model for the use of low-impact, less intrusive techniques. New technology and techniques will be encouraged if they are less intrusive and cause less impact. The goal will be for studies in NPS wilderness to lead the way in 'light on the resource' techniques.

Devices located in wilderness will be removed when determined to be no longer essential. Permanent equipment caches are prohibited within wilderness. Temporary caches must be evaluated using the minimum requirement concept.

All scientific activities, including the installation, servicing, removal, and monitoring of research devices, will apply minimum requirement concepts and be accomplished in compliance with Management Policies, director's orders, and procedures specified in the park's wilderness management plan."

Section 6.4.1 General Policy: Park visitors need to accept wilderness on its own unique terms. Accordingly, the National Park Service will promote education programs that encourage wilderness users to understand and be aware of certain risks, including possible dangers arising from wildlife, weather conditions, physical features, and other natural phenomena that are inherent in the various conditions that comprise a wilderness experience and primitive methods of travel. The National Park Service will not modify the wilderness area to eliminate risks that

are normally associated with wilderness, but it will strive to provide users with general information concerning possible risks, any recommended precautions, related user responsibilities, and applicable restrictions and regulations, including those associated with ethnographic and cultural resources.

Section 8.2.3, Use of Motorized Equipment: "The Service will strive to preserve or restore the natural quiet and natural sounds associated with the physical and biological resources of parks. To do this, superintendents will carefully evaluate and manage how, when, and where motorized equipment is used by all who operate equipment in the parks, including park staff. Uses and impacts associated with the use of motorized equipment will be addressed in park planning processes. Where such use is necessary and appropriate, the least impacting equipment, vehicles, and transportation systems should be used, consistent with public and employee safety."

Section 8.2.5.1, Visitor Safety: "The saving of human life will take precedence over all other management actions as the Park Service strives to protect human life and provide for injury-free visits. The Service will do this within the constraints of the 1916 Organic Act... While recognizing that there are limitations on its capability to totally eliminate all hazards, the Service … will seek to provide a safe and healthful environment for visitors and employees. The Service will strive to identify and prevent injuries from recognizable threats to the safety and health of persons and to the protection of property."

Section 8.2.5.2, Emergency Preparedness and Emergency Operations: "The National Park Service will develop a program of emergency preparedness in accordance with title VI of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 USC 5195-5197g)…"

Section 8.4, Overflights and Aviation Uses: "Although there are many legitimate aviation uses, overflights can adversely affect park resources and values and interfere with visitor enjoyment. The Service will take all necessary steps to avoid or mitigate unacceptable impacts from aircraft overflights."

Director's Order #41: Wilderness Stewardship

Section 6.4, Minimum Requirements: "Parks must complete a "minimum requirements analysis" (MRA) in order to document the determination of whether a proposed action, which involves a prohibited use, is necessary to meet the minimum requirements for the administration of the area for the purpose of wilderness."

Section 6.5, Scientific Activities: "Scientific activities will be encouraged in wilderness, provided that the benefits of what may be learned outweigh the negative impacts to wilderness character."

Mount Rainier National Park Wilderness Management Plan 1992

Administrative Use of Aircraft: "Permission to use helicopters in Wilderness is granted by the Superintendent. Helicopter use in Wilderness, for other than emergencies, will generally not be

approved between July 1 and Labor Day and use is restricted to weekdays. Approval for use of helicopters in non-emergency situations will be granted only if it has been determined to be the minimum tool to achieve the purposes of the area or for protection of Wilderness values."

Research: "Monitoring devices for hydrological, seismic, hydrothermal or other purposes may be installed and operated in Wilderness only when park management has determined that the information is essential and cannot be obtained from a location outside of the Wilderness and the proposed device is the 'minimum tool' necessary to accomplish the study objective. Devices used for monitoring or research purposes are removed when they are no longer essential. All areas are restored to natural conditions at the completion of studies."

Mount Rainier National Park General Management Plan 2002

Geologic Hazards: The plan states, "Increased efforts would be made under the preferred alternative to educate and inform visitors and employees about the threat of geologic hazards and what to do if a debris flow or other event occurred. Such efforts might include…cooperating with the U.S. Geological Survey and others in monitoring geologic hazards in the park."

Time Constraints

What, if any, are the time constraints that may affect the action?

Time constraints on helicopter flights for installation and maintenance would be required for safety reasons and would include flying during daylight hours and avoiding flying during bad weather. Installation work, including helicopter flights, would be limited to September and October. Flights would begin after Labor Day to minimize impacts on visitors and to minimize impacts on nesting northern spotted owls and marbled murrelets. Installations would be completed before November to avoid winter conditions.

Components of the Action

What are the discrete components or phases of the action?

Component 1: Selection of the lahar monitoring locations
Component 2: Transportation of material to the monitoring sites for installation
Component 3: Transportation of personnel to the monitoring sites during installation
Component 4: On-site installation of the monitoring stations
Component 5: Maintenance of the monitoring stations
Component 6: Periodic equipment replacement
Component 7: Emergency repairs to aviation-dependent monitoring sites

MRDG Step 2: Alternatives

Alternative 1: USGS Proposed Action

Description of the Alternative

What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

The goal of the USGS Lahar Detection System proposal is to mitigate human risk by reducing the amount of time it takes for an alert to be sent out to potentially affected populations and communities after a lahar has been generated.

The expansion would also increase the number of total drainage areas covered by the alert system to include the Tahoma Creek and the Nisqually River drainages, which, along with the Puyallup River valley, are vulnerable to future non-eruptive landslide-caused lahars from Mount Rainier. An additional benefit of the expanded monitoring system would be to improve detection capabilities for smaller debris flow events, particularly along Tahoma Creek, which has experienced multiple debris flows since the late 1980s.

Under this alternative, new or upgraded lahar detection stations would be installed at 12 sites in the park, of which 9 would be in wilderness. The sites in wilderness would be Ararat South, Copper Mountain, Emerald Ridge (upgrade to an existing University of Washington site), Fremont Lookout, Gobblers Knob Lookout, Mildred Point, Shriner Peak Lookout, Tahoma Bridge, and Tolmie Peak Lookout. As described below and in Appendix B of the EA, the Fremont Lookout, Shriner Peak, and Tolmie Peak stations would function primarily as telemetry nodes for future stations installed along the Carbon, White, Ohanapecosh/Cowlitz, and Mowich River drainages in the event of future volcanic unrest at Mount Rainier and would not repeat data from any current or proposed stations, although two of the sites (Tolmie and Shriner Peak) would transmit real-time data from on-site seismometers that would collectively improve volcano monitoring capabilities in the park. Instead, these installations would be part of a telemetry backbone that would enable rapid installation of new real-time monitoring stations along the White River drainage, something that would be required to help mitigate lahar hazards along the White River if Mount Rainier were to start exhibiting signs of volcanic unrest. The remaining nine stations would be installed to increase rapid lahar detection capabilities along the west flank of Mount Rainier, which is the most vulnerable to a large lahar down the Puyallup River, Mowich, or Tahoma Creek drainages.

Role of Individual Stations in the Lahar Detection System

Ararat South

The Ararat South site would feature a seismometer and infrasound array and serve as a telemetry repeater for station Mount Wow along Tahoma Creek. Ararat South's roles would include:

- The Ararat South station would provide infrasound and seismometer detection capabilities for a lahar moving down Tahoma Creek, both to confirm that a lahar is moving down the drainage and to determine the location and velocity of the flow front.
- This station would provide redundancy if the monitoring stations at St. Andrews Rock and Emerald Ridge are destroyed by a landslide or lahar.
- The Ararat South station would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer and infrasound array close to the summit.
- This station would improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows, and events on the south and west flanks of the volcano.
- Ararat South would serve as a repeater for station Mount Wow. Without Ararat South, there would be no way to transmit real-time data from Mount Wow, making that site unusable for real-time lahar monitoring.

Copper Mountain

The Copper Mountain site would feature a seismometer, infrasound array, webcam, and GPS receiver. Copper Mountain's roles would include:

- Copper Mountain would provide infrasound detection capabilities for a lahar moving down Tahoma Creek, both to confirm that a lahar is moving down the drainage and to determine the location and velocity of the flow front.
- The webcam at Copper Mountain would play a key role in confirming the location of a landslide and the formation of a lahar.
- Similar to Ararat South, Copper Mountain's seismometer would play an important lahar detection role (see the Ararat South description above).
- Copper Mountain would provide redundancy if the monitoring stations at St. Andrews Rock and Emerald Ridge are destroyed by a landslide or lahar.
- Copper Mountain would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer, infrasound array, and GPS receiver close to the summit.
- The infrasound array and seismometer at Copper Mountain would also improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows on the south and west flanks of the volcano (see the Ararat South description above).

Emerald Ridge – Upgrade of Existing Site

The Emerald Ridge site is an existing seismic station operated by the University of Washington. It would be upgraded to include both a modern seismometer and an infrasound array. Emerald Ridge's roles would include:

- Emerald Ridge would provide infrasound and seismometer detection capabilities for a lahar moving down Tahoma Creek and Puyallup River, both to confirm that a lahar has been created and to help determine which drainage(s) it is moving down.
- Emerald Ridge is the second-closest station to the source area for a landslide on the west flank (St. Andrews Rock is the closest), and also sits on a ridge that divides the Puyallup River and Tacoma Creek drainages. This location is important in two ways:
    - If a large landslide occurs in the northern part of the presumed source area, the closest station (St. Andrews Rock) would likely not survive, so Emerald Ridge would then become the closest station to the source area and would provide information critical to tracking the initial moments of the landslide event and possible transition to a lahar.
    - If a large landslide occurs in the southern part of the presumed source area, modeling indicates that a large lahar would be split by Emerald Ridge and go down both the Puyallup and Tahoma Creek drainages. Modeling also indicates that a large lahar would reach Emerald Ridge in 1 to 2 minutes and likely destroy it, providing early confirmation that a large lahar had been created and was moving down Tahoma Creek.
- Historically, Emerald Ridge has been the only seismic station in the Mount Rainier volcano monitoring network to clearly record small debris flows going down Tahoma Creek. However, telemetry from the site is unreliable at times and the seismometer is out of date. Upgrading the site will improve telemetry reliability and also the fidelity and quality of seismic recordings of debris flows and lahars.
- Emerald Ridge is a critical site in the Mount Rainier volcano monitoring network. It is the closest site to the summit on the southwestern flank and, since its installation in 1991, the site has proven to be quiet and highly sensitive to small earthquakes near the summit. Upgrading the seismometer and improving the reliability of the station would improve the precision and accuracy of earthquake locations beneath Mount Rainier, and the infrasound array would improve the ability of the network to detect explosions.
- Emerald Ridge would operate as a ShakeAlert station (https://www.shakealert.org/), enhancing the earthquake early warning capability at the volcano. Depending on the lahar trigger, a detection from the ShakeAlert system may be one of the earliest signs of a developing landslide.

Fremont Lookout

The Fremont Lookout site would function solely as a telemetry node. A station at Mount Fremont operated by the University of Washington is close to Fremont Lookout, so no seismometer is needed at Fremont Lookout. It would not repeat data from any current or proposed stations. Instead, its installation would be part of a telemetry backbone (along with Tolmie Peak and Shriner Peak) that would enable rapid installation of new real-time monitoring

stations along the White River drainage, something that would be required to help mitigate lahar hazards along the White River if Mount Rainier were to start exhibiting signs of volcanic unrest.

Gobblers Knob

The Gobblers Knob Lookout site would feature a seismometer and would also serve as a telemetry repeater for stations Copper Mountain, Tahoma Bridge, and Tahoma Vista. Gobblers Knob's roles would include:

- Similar to Ararat South and Copper Mountain, the Gobblers Knob's seismometer would play an important lahar detection role (see the Ararat South description above). Although the seismometer at Gobblers Knob would provide data important for tracking lahars along the entire Tahoma Creek drainage, it would be particularly important for tracking lahars down the lower part of Tahoma Creek (along with Mount Wow, Tahoma Vista, and existing stations KAUT and GATE). In addition, if a lahar destroys stations GTWY, KAUT, Emerald Ridge, Tahoma Bridge, Tahoma Vista, and Mount Wow, Gobblers Knob would be the only station still in operation that could provide data necessary for detecting and tracking subsequent lahars and debris flows moving along the lower part of Tahoma Creek.
- Gobblers Knob would serve as a repeater for stations Copper Mountain (Copper Mountain), Tahoma Bridge, and Tahoma Vista. Without Gobblers Knob, there would be no way to transmit real-time data from Copper Mountain, Tahoma Bridge, and Tahoma Vista, making those sites unusable for real-time lahar monitoring.

Mildred Point

The Mildred Point site would feature a seismometer and infrasound array. Mildred Point's roles would include:

- Mildred Point would provide infrasound detection capabilities for a lahar or debris flow moving down the Kautz Creek and Nisqually Creek drainages, both to confirm that a lahar is moving down the drainages and to determine the location and velocity of the flow front.
- Mildred Point's seismometer would also play an important lahar detection role through use of seismic amplitude ratios (see the Ararat South description above).
- Similar to Ararat South and Copper Mountain, Mildred Point would improve volcano monitoring capabilities of the Mount Rainier volcano monitoring network through addition of a seismometer and infrasound array close to the summit.
- The infrasound array and seismometer at Mildred Point would also improve the network's ability to detect and locate "surface events" such as avalanches, rockfalls, and debris flows on the south flank of the volcano including the Nisqually glacier.

Paradise Parking Lot Tower

The Paradise Parking Lot Tower site would serve as a telemetry repeater for stations Ararat South, Mildred Point, and Mount Wow (repeated through Ararat South).

Shriner Peak

The Shriner Peak site would feature a seismometer and would also function as a telemetry node for future stations installed along the Ohanapecosh drainage in the event of future volcanic unrest at Mount Rainier. Shriner Peak's roles would include:

- Shriner Peak's primary role would be as a repeater. It would not repeat data from any current or proposed stations, except for the seismometer at Shriner Peak. Its installation would enable rapid addition of telemetered real-time monitoring stations along the Ohanapecosh drainage that would repeat through Shriner Peak to a receive site outside MRNP. Addition of stations along the Ohanapecosh River would be required to help mitigate lahar hazards to downstream communities if Mount Rainier were to start exhibiting signs of volcanic unrest.
- The seismometer at Shriner Peak would improve the ability of the seismic network to detect smaller lahars and debris flows down the Ohanapecosh River.
- The seismometer at Shriner Peak would also significantly improve the accuracy of earthquake locations at Mount Rainier, particularly in the southeast quadrant of MRNP, which at present has only two seismic stations (RCM (Camp Muir) and OPCH (Ohanapecosh Visitor Center)). The east side of MRNP is an active seismic area, most recently hosting the M4.5 Cowlitz Chimneys earthquake in 2006 that was widely felt in MRNP (Hartog et al. 2008).

Tahoma Bridge

The Tahoma Bridge site would feature a seismometer and a single infrasound sensor. Tahoma Bridge's roles would include:

- A large lahar would likely destroy Tahoma Bridge within 1 to 3 minutes of initiation, providing independent confirmation that a lahar was moving down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- Tahoma Bridge would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. Such information would improve MRNP's situational awareness about such events, potentially improving response time for search and rescue efforts.

Tahoma Vista

The Tahoma Vista site would feature a seismometer and an infrasound array. Tahoma Vista's roles would include:

- If Tahoma Vista is located at Tahoma Vista along the Westside Road, a large lahar would likely destroy Tahoma Vista within 3 to 5 minutes of initiation, providing independent confirmation that a lahar was continuing to move down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- Coupled with infrasound arrays at Copper Mountain and Ararat South, the Tahoma Vista infrasound array would provide complete infrasound coverage of the Tahoma Creek drainage down to its confluence with the Nisqually River.

- Tahoma Vista would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. Such information would improve MRNP's situational awareness about such events, potentially improving response time for search and rescue efforts.

Tolmie Peak

The Tolmie Peak Lookout site would feature a seismometer and would also function as a telemetry node for future stations installed along the Carbon and Mowich River drainages in the event of future volcanic unrest at Mount Rainier. Tolmie Peak Lookout's roles would include:

- Tolmie Peak Lookout's primary role would be as a repeater. It would not repeat data from any current or proposed stations, except for the seismometer at Tolmie Peak. Its installation would enable rapid addition of telemetered real-time monitoring stations along the Carbon and Mowich River drainages, which would repeat through Tolmie Peak Lookout to a receive site outside MRNP. Addition of stations along the Carbon and Mowich Rivers would be required to help mitigate lahar hazards to downstream communities if Mount Rainier were to start exhibiting signs of volcanic unrest.
- The seismometer at Tolmie Peak Lookout would significantly improve the accuracy of earthquake locations at Mount Rainier, particularly in the northwest quadrant of MRNP, which at present has only two seismic stations (Carbon Ranger Station (CRBN) and Observation Rock (OBSR)).

Mount Wow

The Mount Wow site would feature a seismometer and a single infrasound sensor. Mount Wow's roles would include:

- A large lahar would likely destroy Mount Wow within 5 to 7 minutes of initiation, providing independent confirmation that a lahar was continuing to move down Tahoma Creek and also providing information important for determining the velocity and size of the lahar.
- Mount Wow would also provide seismic and infrasound data important for constraining the timing and velocity of smaller lahars and debris flows. In particular, the Mount Wow location is in the area where many recent debris flows have come close to or damaged the Westside Road; it is therefore uniquely situated to provide MRNP with situational awareness about events that may have impacted the Westside Road, potentially improving response time for repairs as well as search and rescue efforts.

A summary of the design process for the Mount Rainier lahar detection system and a detailed description of each site's individual role in the lahar detection system is included in the EA as Appendix B. Additional construction details are found in the EA.

Motorized Equipment (Power Tool) Use for Installation

The USGS proposes the use of the following power tools during the installation of the proposed Mount Rainier lahar detection infrastructure at stations located in the areas designated as

wilderness. Additionally, the USGS proposes the use of many of the same tools to conduct maintenance at these stations as needed. The tools include:

- Battery-powered drill (e.g., DeWalt 20v lithium battery ½-inch drill) for drilling holes in pipes, enclosures, and solar panel frames as needed.
- Battery-powered rock drill for drilling up to 1-inch-diameter holes at the Mount Wow alternative site (e.g., the "talus" site) and Tahoma Bridge to anchor enclosures.
- Battery-powered sawzall (e.g., DeWalt 20v lithium battery 1 1/8-inch stroke reciprocating saw) for cutting pipe, damaged hardware, and 2-inch U-bolts that become cross-threaded during installation or subsequent maintenance.
- Battery-powered bandsaw (e.g., DeWalt 20v lithium battery cordless band saw) for cutting pipe on-site during installation or subsequent maintenance.
- For installing the GPS monument at Copper Mountain, the following power tools are proposed:
    - A 4000W gas-powered generator to operate corded power tools needed for building the short-braced GPS monument.
    - An AC-powered handheld hammer drill to drill four 1.5-inch-diameter and 6-foot-deep holes into bedrock.
    - An AC-powered 1-gallon air compressor for powering a pneumatic epoxy dispenser.
    - A small portable AC-powered welder to tack weld the three angled legs of the GPS monument to the central vertical rod (required for stabilizing the monument).
    - A battery-powered vacuum (DeWalt 20v lithium battery) for removing fine dust out of the 6-foot-deep GPS monument holes.
    - A battery-powered hand grinder with cut off wheel (DeWalt 20v lithium battery).

All Stations

The proposed fiberglass enclosures are designed to be streamlined, self-efficient, and almost entirely prebuilt off-site prior to installation. Power tool use during installation of the fiberglass enclosures would be on an as-needed basis and would be limited to minutes-long durations only.

Tahoma Bridge

The hut enclosures must be secured to the ground to a shallow depth to prevent any movement on sloping terrain. Because the Tahoma Bridge station enclosures are, by necessity, installed on a rock surface, this requires drilling holes in the rock to install J bolts that secure the base (flange) of the hut to the ground using compact cordless SDS Max rotary hammer drills.

Copper Mountain

Installation of the GPS monument at the Copper Mountain site would include the use of additional motorized equipment – specifically, a generator, a welder, a small air compressor, a pneumatic adhesive dispenser, and a hammer drill as described above.

Motorized Equipment (Power Tool) Use for Maintenance

Short- and long-term ice, snow, and wind damage may create unanticipated situations where additional modifications to the solar panel frames and telemetry infrastructure will be necessary to repair damaged equipment. Such repairs would be accomplished using the same power tools noted above, except for those needed only for the installation the GPS monument at Copper Mountain. Modifications to metal infrastructure, especially steel and aluminum, would be accomplished with power drills and saws because of the type and thickness of the metal.

Specific examples where use of power tools is proposed during maintenance include:

- Replacement of lightning protection that has failed or was damaged at a location near a ground rod attached to the enclosure.
- Drilling precision holes in the solar panels or the enclosure to adjust or repair damaged solar panel mounting.
- Removal of or cutting off large stainless steel bolts that have been damaged by snow and ice conditions or are rusted, seized, or cross-threaded.
- Adjustments and replacement of metal pipes or angle brackets used for solar panel framing damaged by ice, snow, or wind loading. In this case, both a drill and saw would be used in very limited durations to remove old rusted or damaged hardware and secure new pipe and hardware as needed.

A description of the power tools to be used and a detailed rationale for power tool use is provided in Attachment A.

Landing of Aircraft (Helicopter Sling Load Delivery) for Installation

The sites within wilderness would require the use of helicopters for initial installation and subsequent maintenance. Installation would require up to seven round trips to each project location by a small helicopter carrying sling loads. Helicopters used would be small (such as A-Stars, Bell Jet Rangers, or Hughes 500 series). Helicopters would take off from the Kautz helibase or the Sunrise parking area (available only in late September/October). The total number of helicopter flights would be about 63 during installation over a 2-month period (September and October). Sites would be evaluated one-year post-installation to determine if active restoration is needed to restore natural conditions at monitoring sites. Should revegetation be necessary, helicopter flights may be required to transport seedlings to areas where transport on foot is infeasible. This would require up to two flights per site where active revegetation is needed – one flight to deliver seedlings and one flight to remove supplies after planting. With the addition of potential flights for revegetation, up to eight total round-trip flights would be needed for each site for installation, and the total number of round-trip flights associated with installation would be about 72. Flights would last for 1 to 2 hours per day at each site and be scheduled for a 2-day period during the months of September and October for 2 consecutive years. Cumulative flight time for installation of all sites would be about 36 to 72 hours.

Landing of Aircraft (Helicopters) for Maintenance

Sites would typically be accessed by foot for routine tuning and maintenance, but additional helicopter flights would be required for anticipated equipment and battery replacement, requiring four round trips per site every 5 years. Tuning refers to unexpected adjustments or repairs to stations within the first two years after installation. The USGS has found that that some sites require tuning after installation, which sometimes requires helicopter use to deliver heavy or bulky equipment, or to remove damaged equipment. Additional flights may also be needed if urgent repairs are required and foot access is not available, for example during winter months. About 219 maintenance flights would be performed over a period of 30 years. Flight time for maintenance would be about 110 to 219 hours for maintenance flights over a period of 30 years. Flights for tuning and emergency repairs are included in this total. Flights for emergency repairs could potentially occur in months other than September and October.

For comparison, the total number of flight hours in the park from 2015 to 2019 averaged 142 flight hours per year, consisting mostly (about 95 percent) of small helicopters, and a small proportion (less than 5 percent) consisting of large helicopters such as CH-47 Chinook and Blackhawk. Helicopter use for Alternative 1 and the other alternatives is summarized in Step 2: Alternatives Comparison in Table 1.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Nine out of 12 stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported by helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 1 would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems inside wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Alternative 1 would have both permanent and temporary effects on the undeveloped quality of wilderness. Construction activities would introduce noise and sights of additional human occupation, which would adversely affect the undeveloped quality of the wilderness. Use of mechanized equipment, such as power tools, and landing of aircraft (helicopters) for material delivery would introduce unnatural sounds during installation and maintenance work. Use of power tools is described in Attachment A. Impacts on the undeveloped quality during construction would generally be low, and disturbance would be mostly contained to a brief construction period at each site. Elevated noise levels from the use of mechanized equipment would occur during construction for a period lasting 2 to 3 days at each site. Use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be about 72 during installation over a 2-month period (which would occur September-October 2021 and possibly extend into September-October 2022 depending on weather conditions and other factors) and about 219 maintenance flights over a period of 30 years. This would represent an increase of about 25 to 50 percent in flight time during the 1- to 2-year installation period and an increase of about 3 to 5 percent in flight time compared to the existing number of flights over the 30-year maintenance period. Helicopters would deliver materials to the project sites via sling loads during installation. Maintenance flights would also involve sling loads to deliver and remove heavy equipment. Crews would hike to the sites to reduce the number of flights for both installation and maintenance. Maintenance flights could also involve landings in the wilderness if critical outages occur when sites are not accessible by foot.

After installation, the presence of new structures and installations at Emerald Ridge, Ararat South, Copper Mountain, Mildred Point, and Tahoma Bridge would degrade the undeveloped wilderness quality by introducing visible signs of human occupation. Under this alternative, the number of standalone seismic installations in wilderness would increase from 5 to 9. The other installations would be collocated with existing developments and installations. The number of stations dependent on aircraft would increase from 5 to 13. As previously described, the physical footprint of all installations in wilderness would be less than 0.1 acre within the Mount Rainier Wilderness, which totals 228,400 acres. The installation locations were designed to minimize visibility to the greatest extent practicable by using screening from vegetation and topography. Stations would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the sites would be potentially visible to the public from nearby as well as from a distance, including popular peaks and viewpoints. Installation of the sites at Emerald Ridge, Ararat South, Copper Mountain, and Mildred Point would affect relatively unimpacted sites with large viewsheds within designated wilderness, mostly within the upper Tahoma Creek watershed. These sites would be situated so they would be hard to see from established trails; however, visitors travelling off trail could come across these facilities or see them from a distance. Wilderness users encountering these facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation.

The installation on Ararat South would be encountered by some hikers climbing to the summit and would tend to dominate the experience of the highest point on the summit; however, the summit is broad and visitors exploring the summit area could find places where the installation is not visible. The installation at Mildred Point would be out of sight of the majority of hikers who do not venture past the end of the maintained trail; however, for some hikers continuing up the ridge to experience the area without the aid of recreational developments, the installation would be encountered and dominate the experience of the area within several hundred feet. The Mildred Point site would also be visible from a distance from many of the higher elevations of Van Trump Park.

The Copper Mountain site would be partially visible to climbers attempting the summit but would not dominate the experience of the undeveloped summit or interfere with views of Mount Rainier or the surrounding landscape. The installation at Emerald Ridge would not be visible to the majority of on-trail hikers but would be encountered by visitors exploring the area without the aid of recreational developments and would tend to dominate the experience of the location within 100 to 200 feet or greater. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely. The Tahoma Bridge site would be mostly screened from view by vegetation and would not likely be seen by visitors but would dominate the experience of a visitor who ventured a short distance off trail to the outcrop, which currently provides an elevated view of the Tahoma Creek drainage out of sight of the more highly visited Wonderland Trail and suspension bridge.

The Fremont Lookout, Gobblers Knob, Shriner Peak, and Tolmie Lookout sites would be collocated with existing lookout structures, thus reducing the impacts on the undeveloped wilderness quality. The fire lookouts predate the wilderness designation and contribute to

wilderness character as historic features and through their necessity for the provision of communication infrastructure and other administrative uses. The additional impact of adding solar panels or buried seismometers at these sites would be consistent with those administrative uses.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☒	☐
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 1 would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, Alternative 1 would have only minimal adverse effects on plants, animals, air, water, or ecological processes. There would be some site-specific negative impacts on natural resources (soils, vegetation, and soundscape) during installation, and potentially maintenance, of structures in currently undeveloped wilderness. It is also possible that foot traffic from maintenance visits or curious visitors could cause the development of social trail impacts where they do not currently exist. Noise and activity from construction and helicopters have the potential to affect breeding and roosting behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. Impacts would affect individuals encountering aircraft as well as those who could hear the aircraft from distant locations. These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary, limited to about 63 trips during installation over a 2-month period (September and October) in 2021 with extension into September-October 2022 if installations are not completed in 2021. With the addition of potential flights for revegetation, up to eight total round-trip flights would be needed for each site for installation, and the total number of round-trip flights associated with installation could be up to 72. About 219 maintenance flights would occur over a period of 30 years.

After installation, the structures would have small effects on solitude or unconfined recreation. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who came across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The stations might serve as curiosities that attract more users to the sites but would not reduce opportunities for solitude or primitive and unconfined recreation overall. As described under the undeveloped quality, stations would be painted to reduce their visibility and placed to minimize being detected by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Nine out of 12 stations would be within wilderness	☒	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The four proposed monitoring stations on the Fremont, Gobblers Knob, Shriner Peak, and Tolmie Peak fire lookouts would affect contributing features to the National Historic Landmark District. Impacts on these features are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. These historical structures predate the wilderness designation and contribute to wilderness character to the extent that they tell the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public.

The dynamic glacial and volcanic features of Mount Rainier contribute to wilderness character as a geologic feature of value, as identified in the park's Wilderness Character Narrative. Study of these unique features would fulfill the public purposes of scientific and educational use. Data collected using the detection sites would be useful to the park for hazard mitigation and situational awareness for wilderness users. The data collected could ultimately lead to an improved ability to detect and characterize debris flows on Mount Rainier as well as other volcanoes around the world, and would enable the park to better inform visitors, including wilderness users, of local hazards. Data collected would benefit the broader scientific community, including enhancing detection ability and understanding of rockfall, glacial dynamics, flooding, and other processes. Finally, the proposed stations would improve volcano monitoring capabilities, including the ability to detect anomalous small earthquakes and small amounts of surface deformation that often precede eruptions, and also to detect explosions that often accompany volcanic unrest and eruption.

MRDG Step 2: Alternatives

Alternative 2: No Action Alternative

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

Under the No Action Alternative, the NPS would not approve the USGS permit to install additional lahar monitoring stations. Monitoring of volcanic activity at MRNP would be conducted at existing monitoring stations (see Figure 1 of the EA). Current monitoring stations include the following:

- Camp Schurman
- Camp Muir
- Carbon River Ranger Station
- Emerald Ridge
- Kautz Creek
- Longmire
- Mount Fremont (approximately 0.7-mile northeast of the lookout)
- Nisqually Gateway
- Observation Rock
- Ohanapecosh
- Panhandle Gap
- Paradise Parking Lot
- Paradise Precipitation Tower
- Ski Dorm
- St. Andrews Rock (located inside the Sunset Amphitheater)
- Sunrise

The USGS would continue to monitor volcanic activity at the seismic and GPS monitoring sites listed above and maintain these sites as needed. From 2009 to 2019, the USGS flew 47 total helicopter sling loads to 6 aircraft-dependent sites (4 in wilderness), which is about 8 flights per site over 11 years. The USGS estimates that about 3 to 4 maintenance trips per site would be needed every 5 years for the five existing monitoring sites in wilderness that are helicopter dependent, for a total of about 120 flights over 30 years.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Maintenance of the existing monitoring stations	Access sites on foot for routine tuning and maintenance work.
2	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
3	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would not adversely affect the untrammeled quality. Continued maintenance of the existing stations would not increase human manipulation or control of the components or processes of ecological systems within wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Maintenance of existing stations would have temporary effects on the undeveloped quality of wilderness. Use of motorized equipment, such as power tools and landing of aircraft (helicopters sling load) for material delivery, would introduce unnatural sounds during installation and maintenance work. No new monitoring sites would be constructed in wilderness.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The No Action Alternative would have negligible new impacts on vegetation within the 228,400-acre wilderness, resulting in minimal adverse effects on plants, animals, air, water, or ecological processes. As described for Alternative 1, noise and activity from construction and helicopters have the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. As described for Alternative 1, helicopter use would be temporary. Helicopter use would be less than under Alternative 1, involving an estimated 120 maintenance flights over a period of 30 years.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
2	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
3	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
No new impacts would occur to historic structures. No new data would be collected using the new detection sites because the new sites would not be installed. The benefits to the park and USGS for hazard mitigation and situational awareness for wilderness users described for Alternative 1 would not occur.

MRDG Step 2: Alternatives

Alternative 3 USGS proposal with alternative sites

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

This alternative would be the same as the USGS Proposed Action, except for specific locations where a modification to the proposal is included to avoid or minimize potential for adverse effects on historic properties. Alternative sites were identified for Fremont Lookout, Mount Wow, Shriner Peak, Tahoma Vista, and Tolmie Peak. This alternative is described in greater detail in the EA.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Eleven out of 12 stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported with helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems inside wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
The alternative station sites would have both permanent and temporary effects on the undeveloped quality of wilderness. Use of motorized equipment, such as power tools and landing of aircraft (helicopters) for material delivery, would introduce unnatural sounds during installation and maintenance work. Under this alternative, both Mount Wow and Tahoma Ridge would be installed and maintained by aircraft. This increases the number of aircraft-dependent sites in wilderness from 5 to 15.

As described for the USGS Proposed Action, impacts on the undeveloped quality during construction would generally be low, and elevated noise levels from the use of mechanized equipment would occur during construction over a two-week period each year over two years while use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be greater than under the USGS Proposed Action, with about 88 trips (16 more than the USGS Proposed Action) during installation over a two-month period (September and October) and about 273 maintenance flights over a period of 30 years (54 more than the USGS Proposed Action). This would represent an increase of about 31 to 62 percent in flight time during the 2-year installation period and an increase of about 4 to 6 percent in flight time compared to the existing number of flights over the 30-year maintenance period.

All five of the alternative sites at Fremont Peak, Mount Wow Talus, Shriner Peak Alternative, Tahoma Vista Ridge, and Tolmie Peak Alternative would introduce visible signs of human disturbance to the wilderness. The Mount Fremont station would not be visible from the Fremont Lookout but would be visible in the distance from the Wonderland Trail and would be highly visible to anyone venturing beyond the end of the maintained Mount Fremont Trail. The Mount

Wow Talus station would be highly visible from Westside Road. The Shriner Peak Alternative would be screened from view from the Lookout Tower by vegetation but would have the potential to dominate the experience of a visitor venturing beyond the end of the maintained trail or navigating to the summit before the trail is melted out. The Tahoma Vista Ridge site would be in a location that is rarely visited and is not accessed by any routes or way trails. The Tolmie Peak Alternative site would not be visible from the Tolmie Lookout; however, it would have a large viewshed into the upper Carbon and upper Mowich drainages and would be located on a social trail accessed from the main trail leading to the lookout, with a high likelihood of being encountered by visitors (several hundred per day during peak periods).

The total footprint of the installations in wilderness would be greater than under Alternative 1 but would still be less than 0.1 acre. Under this alternative, the number of standalone installations in currently pristine wilderness would increase from 5 to 14, twice as many new, standalone installations as Alternative 1. The alternative installation locations were designed to minimize visibility to the greatest extent practicable by using screening from vegetation and topography. The Tahoma Vista Ridge site would be unlikely to be encountered by visitors due to its remote location away from any way trails, named peaks, or travel routes. Wilderness users encountering Mount Fremont, Mount Wow Talus, Shriner Peak Alternative, or Tolmie Peak Alternative facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☒	☐
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
This alternative would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures

to reduce impacts, the action would have minimal adverse effects on plants, animals, air, water, or ecological processes, but greater effects than Alternative 1. However, there is a possibility that foot traffic from maintenance visits or curious visitors could cause the development of social trail impacts where they do not currently exist. As described for Alternative 1, noise and activity from construction and helicopters has the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. As described for Alternative 1, helicopter use would be temporary. Helicopter use would be greater than under Alternative 1, increasing to 77 trips during installation, up to 11 trips for revegetation, and about 273 maintenance flights over a period of 30 years.

After installation, the structures would have greater effects on solitude or unconfined recreation relative to Alternative 1. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who came across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The presence of the stations might serve as curiosities that attract more users to the sites. Sites would be located close to popular destinations and would therefore be more likely to be encountered by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude. The opportunity for solitude in an unmodified setting, without the aid of recreational developments, is uniquely protected by the wilderness designation, when compared to other

public lands. In this alternative, the difficulty of finding a pristine site to experience solitude away from the frequently visited lookout structures would be increased, and opportunities for solitude would be reduced relative to the USGS Proposed Action.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Eleven out of 12 stations would be within wilderness	☒	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
One proposed monitoring station on Gobblers Knob, would affect a contributing feature to the National Historic Landmark District. Impacts to this feature are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. This historical structure predates the wilderness designation and contributes to wilderness character to the extent that it tells the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structure as a historic feature toward a perception as a modern administrative facility. As described above under the undeveloped quality, stations could potentially have adverse effects on scenic quality, especially the Mount Wow Talus and Tolmie Peak Alternative sites, which would be highly visible. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public. In addition, the Mount Wow alternate site would not be within the footprint of the historic Westside Road corridor but would be visible on the talus slope nearby.

As in Alternative 1, study of Mount Rainier's geologic features would fulfill the scientific and educational purposes of wilderness. Data collected using the detection sites would also be useful to the park for hazard mitigation and situational awareness for wilderness users. These benefits would be the same as described for Alternative 1.

MRDG Step 2: Alternatives

Alternative 4: Modified Lahar Detection and Volcano Monitoring with deferred installation at three locations (Fremont, Tolmie, Shriner) contingent on future evidence of volcanic unrest

Description of the Alternative

What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

This alternative would reduce the number of installations by eliminating the Tolmie Peak, Fremont, and Shriner Peak monitoring sites from the proposal. The primary role at these three locations is to function as a repeater for future stations in the event of future volcanic unrest at Mount Rainier. Elimination of these three installation sites would reduce the total number of new installations in wilderness in the near term by deferring installation to a later date after volcanic unrest has been detected. This would require rapid deployment of both additional real-time monitoring stations and repeaters in the event volcanic unrest at Mount Rainier were to occur in the future. Elimination of the Tolmie Peak and Shriner Peak sites would also eliminate the addition of seismometers that would otherwise improve the accuracy of earthquake locations at Mount Rainier and the ability to detect smaller lahars and debris flows down the Carbon, White, Ohanapecosh/Cowlitz, and Mowich River drainages. Elimination of these sites would also reduce volcano monitoring capabilities. A summary of the design process for the Mount Rainier lahar detection system and a detailed description of each site's individual role in the lahar detection system is included in the EA as Appendix B.

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Six out of nine stations would be within wilderness.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported by helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☐	☒
2	All materials and equipment would be transported by helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 4 would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems in wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Construction activities would introduce noise and sights of additional human occupation, which would adversely affect the undeveloped quality of the wilderness. Use of motorized equipment, such as power tools and landing of aircraft (helicopters) for material delivery, would introduce unnatural sounds during installation and maintenance work. Use of power tools is described in Attachment A. Impacts on the undeveloped quality during construction would generally be low, and disturbance would be mostly contained to a brief construction period at each site. Elevated noise levels from the use of mechanized equipment would occur during construction over a two-week period each year over two years while use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be less than under the USGS Proposed Action, with about 48 trips (24 fewer than the USGS Proposed Action) during installation over a 2-month period (September and October) and about 138 maintenance flights over a period of 30 years (81 fewer than the USGS Proposed Action). This would represent an increase of about 17 to 34 percent in flight time during the 2-year installation period and an increase of about 2 to 3 percent in flight time compared to the existing number of flights over the 30-year maintenance period. Crews would hike to the sites to reduce the number of flights for both installation and maintenance.

After installation, the presence of new structures and installations at Emerald Ridge, Ararat South, Copper Mountain, Mildred Point, and Tahoma Bridge would degrade the undeveloped wilderness quality by introducing visible signs of human occupation. Under this alternative, the number of standalone seismic installations in wilderness would increase from 5 to 9. The other installations would be collocated with existing developments and installations. The number of stations dependent on aircraft would increase from 5 to 10. Installation of the sites at Emerald

Ridge, Ararat South, Copper Mountain, and Mildred Point would affect relatively unimpacted sites with large viewsheds within designated wilderness, mostly within the upper Tahoma Creek watershed. These sites would be situated so they would be hard to see from established trails; however, visitors travelling off trail could come across these facilities or see them from a distance. Wilderness users encountering these facilities could feel that their wilderness experience has been degraded by the presence of these signs of human occupation.

As previously described, the installation on Ararat South would be encountered by some hikers climbing to the summit and would tend to dominate the experience of the highest point on the summit; however, the summit is broad and visitors exploring the summit area could find places where the installation is not visible. The Gobblers Knob Lookout site would be collocated with an existing lookout structure, thus reducing the number of installations and visual impacts on the undeveloped wilderness quality. The installation at Mildred Point would be out of sight of most hikers who do not venture past the end of the maintained trail; however, for some hikers continuing up the ridge to experience the area without the aid of recreation developments, the installation would be encountered and dominate the experience of the area within several hundred feet. The Mildred Point site would also be visible from a distance from many of the higher elevations of Van Trump Park. These impacts would persist for as long as the lahar detection sites are present in the wilderness, potentially indefinitely.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☒	☐
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 4 would alter less than 0.1 acre of vegetation within the 228,400-acre wilderness, and impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, Alternative 4 would have only minimal adverse effects on plants, animals, air, water, or ecological processes. However, there is a possibility that foot traffic from maintenance

visits or curious visitors could cause the development of social trail impacts where they do not currently exist. As described for Alternative 1, noise and activity from construction and helicopters has the potential to affect behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☐	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. Impacts would affect individuals encountering aircraft as well as those who could hear the aircraft from distant locations. These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary and limited to about 42 trips during installation, up to 6 flights for revegetation, and about 138 maintenance flights over a period of 30 years.

After installation, the structures would have small effects on solitude or unconfined recreation. The presence of the monitoring stations would negatively affect the primitive nature of the wilderness. Individuals who come across a site could have their wilderness experience negatively affected by the feeling of being monitored and by the feeling that modern humans have occupied and will return to the site. The stations might serve as curiosities that attract more users to the sites but would not reduce opportunities for solitude or primitive and unconfined recreation overall. As described under the undeveloped quality, stations would be painted to reduce their visibility and placed to minimize being detected by the casual visitor. However, the greatest impact would be experienced by the visitor who expends the greatest effort to pursue the opportunity for solitude, and therefore has a higher expectation of solitude.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of nine stations would be within wilderness	☒	☒	☐
2	All materials and equipment would be transported by helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The proposed monitoring station on the Gobblers Knob fire lookout would affect contributing features to the National Historic Landmark District. Impacts on these features are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. These historical structures predate the wilderness designation and contribute to wilderness character to the extent that they tell the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public.

The dynamic glacial and volcanic features of Mount Rainier contribute to wilderness character as a geologic feature of value, as identified in the park's Wilderness Character Narrative. Study of these unique features would fulfill the public purposes of scientific and educational use. Data collected using the detection sites would be useful to the park for hazard mitigation and situational awareness for wilderness users, as described for the other alternatives. Elimination of the Tolmie Peak and Shriner Peak sites would eliminate the addition of seismometers that would otherwise improve the accuracy of earthquake locations at Mount Rainier and the ability to detect smaller lahars and debris flows down the Ohanapecosh River. Other than the elimination of data from these two sites, the data collected under Alternative 4 would be the same as the other alternatives.

MRDG Step 2: Alternatives

Alternative 5: **Install new stations in wilderness only in locations with existing or previously authorized developments; do not install new stations in undeveloped wilderness.**

Description of the Alternative
What are the details of this alternative? When, where, and how will the action occur? What mitigation measures will be taken?

This alternative would include all stations as proposed in Alternative 1, except Ararat South, Copper Mountain, and Mildred Point. This would avoid new impacts on wilderness character in the locations that are currently least developed and least impacted by modern human activities. Other installations would be collocated with existing fire lookouts, on or near the Westside Road (Mount Wow (TAWO) and Tahoma Vista (TAVI)), or near the large man-made suspension bridge across Tahoma Creek (TABR). This alternative would also eliminate the need for the Paradise Parking Lot Tower installation (which would receive signals from Ararat South and Mildred Point).

Under this alternative, new lahar detection stations would be installed at up to 9 sites in the park, of which 6 would be in wilderness. The sites in wilderness would be Emerald Ridge (upgrade to an existing University of Washington site), Fremont Lookout, Gobblers Knob Lookout, Shriner Peak Lookout, Tahoma Bridge, and Tolmie Peak Lookout. As described in Alternative 1 and in Appendix B of the EA, the Fremont Lookout, Shriner Peak, and Tolmie Peak stations would function primarily as telemetry nodes for future stations installed along the Carbon, White, Ohanapecosh/Cowlitz, and Mowich River drainages in the event of future volcanic unrest at Mount Rainier. Two of the lookout sites (Tolmie Peak and Shriner Peak) would also feature seismometers; one site (Fremont) would not repeat data from any current or proposed stations. Since Ararat South would serve as a data repeater for the Mount Wow site, an alternative means for transmitting real-time data from the Mount Wow site (such as installing a data cable along the Westside Road) would need to be implemented. If an alternate solution cannot be found for transmitting data from the Mount Wow site, then Alternative 5 would eliminate 5 of the 12 station installations proposed in Alternative 1.

This alternative would have utility in improving detection of large events with the potential to seriously impact downstream communities. However, it would reduce the number of stations installed or upgraded in the Tahoma Creek drainage area from 8 to 4 or 5, which would result in significant degradation in lahar detection capabilities in several ways:

(1) The number of sites with infrasound detection capabilities would be reduced to only Emerald Ridge, Tahoma Vista, and Tahoma Bridge (Ararat South, Copper Mountain, and Mildred Point would all feature infrasound arrays). Emerald Ridge would likely be destroyed within 1 minute of lahar initiation, leaving Tahoma Vista and Tahoma Bridge as the only infrasound-capable sites

in operation (and Tahoma Vista as the only site with an infrasound array). This would result in significant degradation in infrasound-based lahar detection and flow-tracking capabilities. Infrasound waves, like other sound waves, are heavily impacted by topography. Since Tahoma Bridge and Tahoma Vista are located on the floor of the Tahoma Creek drainage, it is likely that neither site would detect lahar-generated infrasound signals because of topographic obstructions until a lahar reached the southward bend in the drainage, adding minutes of delay time to a potential alarm.

(2) Mildred Point, Copper Mountain, and Ararat South are all in seismically quiet locations that are reasonably close (less than 6 miles) to the summit and west flank, which makes them ideal sites for seismic monitoring and especially for detecting small earthquakes (magnitude less than 1) that could be precursors to an eruption or a large failure of the west flank (small earthquakes were observed up to several weeks prior to a large landslide in 2009 near Naches, Washington (https://historylink.org/File/9224)). Of the remaining proposed sites, Mount Wow, Tahoma Vista, and Tahoma Bridge would all be exposed to river noise and would not be useful for detecting small earthquakes, and Gobblers Knob would be too far (more than 8 miles) to detect small earthquakes, leaving Emerald Ridge as the only new/upgraded site that would be quiet enough and close enough to detect small earthquakes. Since a seismic station already exists at Emerald Ridge, this alternative would result in no improvement in the ability to detect and locate small precursory earthquakes at Mount Rainier.

(3) Without Mildred Point, Copper Mountain, and Ararat South, the reliability and timeliness of seismic-based lahar detections would be significantly impacted. A large west flank lahar would likely destroy existing stations at Emerald Ridge and St. Andrews Rock; without Mildred Point, Copper Mountain, and Ararat South, the closest stations then would be the existing sites at Paradise, Observation Rock, and Longmire, as well as those proposed at Tahoma Bridge and Tahoma Vista, none of which is closer than 5 miles to the source area. This would result in significant degradation in the ability of the USGS to confirm the presence of a lahar as well as to determine which drainage it is traveling down. Confirmation of a lahar traveling down Tahoma Creek would only come from the destruction of the Tahoma Bridge station, which would occur approximately 3 to 4 minutes after lahar initiation, leaving only approximately 6 to 8 minutes before the lahar would reach the main park road and entrance station area. When only a short window of time is available to detect an event and provide emergency hazard notification, every available minute is essential.

(4) At present there is no continuous GPS site in operation on the western and southwestern flanks of Mount Rainier (the closest GPS sites are at Observation Rock, Camp Muir, and Paradise). This gap represents the largest hole in the USGS monitoring network at Mount Rainier. Without Copper Mountain, there would be no improvement in GPS-based volcano monitoring capabilities at Mount Rainier. In addition, Copper Mountain would be the closest operating GPS site to the potential failure area; without Copper Mountain, the USGS would be unable to detect any subtle precursory deformation of the west flank that may precede a flank failure (precursory deformation was observed for a number of weeks prior to the May 18, 1980, eruption of Mount St. Helens, which was initiated by a large landslide).

In addition, an alternative means of obtaining real-time data from the Mount Wow station would need to be devised, such as a hard-wired data conduit to another transmitting station, or it would not be usable for real-time data. One such option would be running fiber optic cables up Westside Road. To reach the station as it is currently sited, such a cable would need to span the drainage to the north of the trailhead so as not to be damaged by frequent small debris flows that regularly damage the road at that point. If the station were sited to the south of the drainage, then power, along with a fiber optic cable, would need to be run up Westside Road. Without the Mount Wow site, there would be significant loss in the detection system's capability to provide situational awareness about the progression of a large lahar down Tahoma Creek, and also smaller and more frequent debris flows that often reach as far as the Mount Wow location (see Alternative 1 for a full description of the capabilities that would be enabled by the Mount Wow site).

Component Activities
How will each of the components of the action be performed under this alternative?

Comp #	Component of the Action	Activity for this Alternative
X	*Example: Transportation of personnel to the project site*	*Example: Personnel will travel by horseback*
1	Selection of the lahar monitoring locations	Six out of 9 stations would be located in wilderness, collocated with existing developments.
2	Transportation of material to the monitoring sites for installation	All materials and equipment would be transported by helicopters.
3	Transportation of personnel to the monitoring sites during installation	Personnel would hike to and from the sites.
4	On-site installation of the monitoring stations	Installation would use power tools.
5	Maintenance of the monitoring stations	Access sites on foot for routine tuning and maintenance work.
6	Periodic equipment replacement	Transport replacement batteries and other large or heavy components by helicopter.
7	Emergency repairs to aviation-dependent monitoring sites	Access sites by aircraft when objective hazards preclude access on foot.

Wilderness Character
What is the effect of each component activity on the qualities of wilderness character? What mitigation measures will be taken?

UNTRAMMELED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of 9 stations would be located in wilderness, collocated with existing developments	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 1 would not adversely affect the untrammeled quality. The lahar detection stations would not increase human manipulation or control of the components or processes of ecological systems inside wilderness; therefore, the untrammeled quality of wilderness would be preserved.

UNDEVELOPED

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of 9 stations would be located in wilderness, collocated with existing developments	☐	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☒	☐
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Construction activities would introduce noise and sights of additional human occupation, which would adversely affect the undeveloped quality of the wilderness. Use of motorized equipment, such as power tools and landing of aircraft (helicopters) for material delivery, would introduce unnatural sounds during installation and maintenance work. Use of power tools would be less than in the other alternatives. The use of a gas-powered generator, AC-powered hammer drill, air compressor, welder, vacuum, and grinder needed for the Copper Mountain site would not be required.

Impacts on the undeveloped quality during construction would generally be low, and disturbance would be mostly contained to a brief construction period at each site. Elevated noise levels from the use of motorized equipment would occur during construction over a two-week period each year over two years. The use of a helicopter to transport material would result in a temporary increase in noise that would affect the undeveloped quality of wilderness for about one to two hours per day over a period of about two days at each site. The total number of helicopter flights would be less than under the USGS Proposed Action, with about 48 trips (24 fewer than the USGS Proposed Action) during installation over a 2-month period (September and October) and about 138 maintenance flights over a period of 30 years (81 fewer than the USGS Proposed Action). This would represent an increase of about 17 to 34 percent in flight time during the 2-year installation period and an increase of about 2 to 3 percent in flight time compared to the existing number of flights over the 30-year maintenance period. Crews would hike to the sites to reduce the number of flights for both installation and maintenance. The majority of the flights would be to locations that already receive periodic deliveries of equipment by aircraft.

After installation, the presence of the new site at Tahoma Bridge would degrade the undeveloped wilderness quality by introducing visible signs of human occupation. The number of standalone seismic installations in wilderness would increase from 5 to 6, but the new site would be located near the existing man-made suspension bridge. The other installations would be collocated with existing fire lookouts. The number of monitoring stations in the park that are dependent on aircraft would increase from 5 to 10.

The Fremont Lookout, Gobblers Knob, Shriner Peak, and Tolmie Lookout sites would be collocated with existing lookout structures, thus reducing the impacts on the undeveloped wilderness quality. The fire lookouts predate the wilderness designation and contribute to wilderness character as historic features and through their necessity for the provision of communication infrastructure and other administrative uses. The additional impact of adding solar panels or buried seismometers at these sites would be consistent with those administrative uses.

NATURAL

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of 9 stations would be located in wilderness, collocated with existing developments	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
Alternative 5 would alter less total area than the other action alternatives, and most of the impacts are expected to recover to a natural state over time. Due to the small scale and widely separated nature of the proposed sites, and the implementation of mitigation measures to reduce impacts, Alternative 5 would have only minimal adverse effects on plants, animals, air, water, and ecological processes. Noise and activity from construction and helicopters have the potential to affect breeding and roosting behaviors of spotted owls and marbled murrelets; however, with implementation of mitigation measures, the project is not expected to adversely affect these species.

SOLITUDE OR PRIMITIVE & UNCONFINED RECREATION

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of 9 stations would be located in wilderness, collocated with existing developments	☐	☐	☒
2	All materials and equipment would be transported with helicopters	☐	☒	☐
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☒	☐
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☒	☐

Explain:
Helicopter trips to install monitoring stations would affect solitude when aircraft are flying over or landing in wilderness. Impacts would affect individuals encountering aircraft as well as those who hear the aircraft from distant locations. These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary, limited to about 48 trips during installation over a 2-month period (September and October) in 2021 with extension into September-October 2022 if installations are not completed in 2021. About 138 maintenance flights would occur over a period of 30 years.

Because the installations would be collocated on or near existing developments, the structures would have only minor effects on solitude or unconfined recreation relative to existing conditions.

OTHER FEATURES OF VALUE

Activity #	Component Activity for this Alternative	Positive	Negative	No Effect
X	*Example: Personnel will travel by horseback*	☐	☐	☒
1	Six out of 9 stations would be located in wilderness, collocated with existing developments	☒	☒	☐
2	All materials and equipment would be transported with helicopters	☐	☐	☒
3	Personnel would hike to and from the sites	☐	☐	☒
4	Installation would use power tools	☐	☐	☒
5	Access sites on foot for routine tuning and maintenance work	☐	☐	☒
6	Transport replacement batteries and other large or heavy components by helicopter	☐	☐	☒
7	Access sites by aircraft when objective hazards preclude access on foot	☐	☐	☒

Explain:
The four proposed monitoring stations on the Fremont, Gobblers Knob, Shriner Peak, and Tolmie Peak fire lookouts would affect contributing features to the National Historic Landmark District. Impacts on these features are described in detail in the Historic Districts, Structures, and Cultural Landscapes section of the EA. These historical structures predate the wilderness designation and contribute to wilderness character to the extent that they tell the story of historical use of the wilderness area. Modern installations and modifications contribute to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities. Instruments would be painted to reduce their visibility and placed strategically to minimize detection by the casual visitor; however, several of the instruments would be potentially visible to the public.

The dynamic glacial and volcanic features of Mount Rainier contribute to wilderness character as a geologic feature of value, as identified in the park's Wilderness Character Narrative. Study of these unique features would fulfill the public purposes of scientific and educational use. Data collected using the detection sites would be useful to the park for hazard mitigation and situational awareness for wilderness users. The data collected could ultimately lead to an improved ability to detect and characterize debris flows on Mount Rainier as well as other volcanoes around the world, and would enable the park to better inform visitors, including wilderness users, of local hazards. Data collected would benefit the broader scientific community, including enhancing detection ability and understanding of rockfall, glacial dynamics, flooding, and other processes. Finally, the proposed stations would improve volcano monitoring capabilities, including the ability to detect anomalous small earthquakes and small

amounts of surface deformation that often precede eruptions, and also to detect explosions that often accompany volcanic unrest and eruption.

This alternative would have diminished capability to detect, monitor, and study geologic events in the upper Tahoma Creek and Kautz Creek drainages. Seismic and volcanic activity would be monitored with reduced sensitivity compared to the other action alternatives. There would be detection delays, diminished accuracy, and lack of redundancy that could increase the potential loss of life for wilderness users and downstream communities in the event of a destructive lahar.

MRDG Step 2: Alternatives Not Analyzed

Alternatives Not Analyzed
What alternatives were considered but not analyzed? Why were they not analyzed?

Install USGS Monitoring Stations as Originally Proposed

The original USGS proposal that was submitted to the NPS in December 2019 (see Appendix B of the EA) proposed several sites, five of which were approved and installed in 2020. As described above under the USGS Proposed Action (Alternative 1), MRNP and USGS staff worked collaboratively to refine the USGS proposal for the remaining 12 locations to further mitigate the potential for adverse effects. Although some elements of the original proposal were retained in Alternative 1, the overall proposal was resubmitted and incorporates modifications to several of the proposed monitoring stations as described in the attached PPRs.

Locate All New Long-Term Seismic/GPS Monitoring Stations Outside Wilderness

Placing each of the proposed stations outside wilderness would mean locating them further from the volcano, which would not improve volcano monitoring or lahar detection. Infrasound is most effective when placed near the impacted drainage, as pressure waves in the atmosphere have been shown to be distorted or shadowed by local topography. Instrumentation within and adjacent to the potentially impacted drainages is necessary to assess the extent of the hazard. Alternative 2 (the No Action Alternative) evaluates the effects of not installing any of the proposed new monitoring stations in the Mount Rainier Wilderness.

Increase the Number of Stations Proposed by the USGS

The USGS provided a summary of the larger system that was considered but not included in the proposal. An overall summary regarding the development of the proposal has been provided by the USGS, and specific language about a more robust system is included in the EA under *Alternatives Considered but Dismissed*. However, as described in the EA, additional sites were not considered for this proposal because (a) current scientific understanding is that these other drainages are not as vulnerable to spontaneous non-eruptive landslide-caused lahars, (b) the primary purpose of this project is to improve lahar detection capabilities, not volcano monitoring capabilities, and (c) the impact on wilderness would be far greater. A summary of the design process for the Mount Rainier lahar detection system, including an initial proposal for as many as 40 stations, with about half of the stations within the park, is included in Appendix B of the EA.

Nonmotorized Transport of Materials to the Project Sites

Hiking or horseback transport of materials to and from the project site was not considered given the weight and dimensions of the equipment and the time constraints. The monitoring stations are too heavy to carry to these sites via nonmotorized means.

Installation Using Only Nonmotorized Tools

This alternative is the same as the USGS Proposed Action (Alternative 1) except that no power tools would be used during installation; only hand tools would be used for installation. Helicopters would be used to transport materials and equipment to the project site. Use of hand tools would require additional time for installation, and could potentially require additional helicopter flights, or require flights to extend over a longer period.

This alternative was eliminated from detailed analysis because it would not be practical to eliminate all power tools from the Proposed Action. It would not be possible to achieve the needed precision drilling holes in metal pipe with manual tools. In addition, although cutting metal materials such as trim, bolts, and conduit with a handheld hacksaw may be possible, some cuts would be in areas that are awkward or constricted by other structural elements and would require a different approach to design. Installation would take longer and require a longer weather window, and possibly repeat visits, increasing the duration of temporary impacts on solitude and severity of trampling on vegetation. Finally, hand drilling deep holes, without power tools, would require additional laborers and multiple days of work. The technique was historically used to split, blast, or otherwise destroy rock, and precision drilling for the type of anchors needed for these installations would require an experienced team, which is not available. Manual hand drilling was abandoned in the early 20th century in favor of pneumatic drilling. Although hand drilling is used today for wilderness trail maintenance (breaking rock) or placement of small (several inch long) structural anchors, it is not a viable option for the proposed installations. A detailed summary of the power tools proposed for use and justification for their use is found in Attachment A.

MRDG Step 2: Alternatives Comparison

Alternative 1:	USGS Proposed Action
Alternative 2:	No Action Alternative
Alternative 3:	USGS proposal with alternative sites
Alternative 4:	Modified Lahar Detection and Volcano Monitoring with installation at three locations (Fremont, Tolmie, Shriner) deferred pending evidence of volcanic unrest
Alternative 5:	Modified Lahar Detection and Volcano Monitoring with exclusion of sites in currently undeveloped locations.

Factors to be considered in comparing the alternatives include the effects of each alternative on the qualities of wilderness character and prohibited uses under Section 4(c) of the Wilderness Act. Differences between the alternatives would primarily result from differences in effects on the undeveloped, solitude and opportunities for unconfined recreation, and other features of value qualities of wilderness character.

Prohibited Uses

Alternatives 1, 3, 4, and 5 would include construction of new installations in wilderness and landing of aircraft within wilderness, which are prohibited uses under the Wilderness Act except as found necessary through an analysis of the minimum requirement as defined by the Act. Each helicopter trip would include a landing via sling load to deliver materials. The number of helicopter trips and new installations would vary between the alternatives, as summarized in Table 1. Alternative 3 would require 25 percent more flights than Alternative 1; Alternatives 4 and 5 would require approximately 66 percent of the flights in Alternative 1.

Untrammeled

None of the alternatives would affect the untrammeled quality of wilderness character.

Natural

The action alternatives (Alternatives 1, 3, 4, and 5) would have similar, very minor impacts on the natural quality of wilderness. Of the action alternatives, Alternative 5 would have the smallest impact on the natural quality by minimizing new stand-alone sites. The No Action Alternative (Alternative 2) would not result in new impacts on this quality.

Undeveloped

Use of motorized equipment, such as power tools and landing of aircraft (helicopters) for material delivery, would affect the undeveloped quality of wilderness by introducing unnatural sounds during installation and maintenance work. Use of helicopters would vary between alternatives, as shown in Table 1 below. Power tools would be used for Alternatives 1, 3, 4, and 5. The undeveloped quality of wilderness would also be affected under the action alternatives by the presence of new installations in wilderness. The impacts of the new installations would be similar between the alternatives but would be proportional to the number of new stand-alone stations in wilderness and the number of new stations in undeveloped wilderness (Table 1). Of the action alternatives, Alternative 5 would have the least impacts on the undeveloped quality. Alternative 3 would have the greatest impact. Alternative 1 would have a moderate impact relative to the other alternatives and Alternative 4 would have less impact than Alternative 1, but more than Alternative 5.

Solitude and Opportunities for Unconfined Recreation

The alternatives would result in small differences in temporary impacts on solitude when aircraft are flying over or landing in wilderness, which would be proportional to the number of helicopter flights for each alternative (Table 1). In addition, the structures would have small effects on solitude and opportunities for unconfined recreation after installation, which would vary between Alternatives 1, 3, 4, and 5, depending on the number of new stand-alone stations in wilderness and the number of new stations in undeveloped wilderness (Table 1). Of the action alternatives, Alternative 5 would have the least impacts on this quality, while Alternative 3 would have the greatest. Alternative 1 would have a moderate impact relative to the other alternatives and Alternative 4 would have less impact than Alternative 1, but more than Alternative 5.

Other Features of Value

New stations would be collocated with existing historic fire lookouts at four sites (Alternatives 1 and 5) or one site (Alternatives 3 and 4). No new stations would be collocated with existing historic fire lookouts in Alternative 2 (No Action Alternative). Modern installations and modifications would affect the other features of value quality of wilderness character by contributing to a shift in visitor perception of the structures as historic features toward a perception as modern administrative facilities.

Scientific Purpose/Benefit

Study of Mount Rainier's geologic features would fulfill the scientific and educational purposes of wilderness. Data collected using the detection sites would also be useful to the park for hazard mitigation and situational awareness for wilderness users. These benefits would vary under the four action alternatives, depending on the number and location of monitoring sites. Alternatives 1 and 3 provide the most robust and accurate monitoring and have the most benefit under this purpose. Because utility for public safety is directly linked to the scientific utility, these alternatives also best meet the requirements of the Dingell Act. Alternatives 1, 3, and 4 are

equally useful for early detection of lahars on the west flank of the mountain, but Alternative 4 is less useful for the detection of volcanic unrest. If Mount Rainier began exhibiting signs of unrest, it would take several additional days to establish real-time telemetry capabilities on the north side of the park (and potentially many days if unrest began during the fall/winter storm season), resulting in delays in establishing lahar detection capabilities along the White River drainage. Alternative 5 has the least benefit for this purpose because of the gaps in detection near the locations of greatest interest for the purpose of the project. No change to current data collection would occur under Alternative 2 (No Action).

Table 1. Comparison of Alternatives

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Existing sites requiring helicopter use	5	5	5	5	5
New sites requiring helicopter use	8	0	10	5	5
Site upgrades requiring helicopter use	1	0	1	1	1
Helicopter flights for maintenance of existing sites over 30 years (24 trips per site)[1]	120	120	120	120	120
Helicopter trips for site installation and upgrades (7 trips per site, plus 1 trip per site for revegetation)	72	0	88	48	48
Additional helicopter trips for tuning and maintenance of new sites over 30 years (27 trips per site)[2]	219	0	273	138	138
New stand-alone stations in wilderness	4	0	9	4	1
New stations collocated with historic fire lookouts	4	0	1	1	4

[1]Assumes up to four maintenance trips per site every 5 years for 30 years.

[2]Assumes three trips for tuning after 1 to 2 years plus four trips every 5 years (24 flights) over 30 years for maintenance.

MRDG Step 2: Determination

Refer to the **MRDG Instructions** before identifying the selected alternative and explaining the rationale for the selection.

Recommended Alternative	
☐ Alternative 1:	USGS Proposed Action
☐ Alternative 2:	No Action Alternative
☐ Alternative 3:	USGS proposal with alternative sites
☒ Alternative 4:	Modified Lahar Detection and Volcano Monitoring with installation at three locations (Fremont, Tolmie, Shriner) deferred pending evidence of volcanic unrest
☐ Alternative 5:	Modified Lahar Detection and Volcano Monitoring with exclusion of sites in currently undeveloped locations.

Explain Rationale for Recommended Alternative:

Alternative 4 best meets the purpose and need of the project while minimizing impacts on wilderness character by ensuring reliable, accurate, and timely detection of potentially life-threatening hazards that may affect wilderness users, park administrative areas, and downstream communities.

The primary impacts from Alternative 4 are on the undeveloped quality of wilderness and opportunities for solitude. The alternative will double the number of monitoring installations in wilderness, which necessitates an increase in the use of motorized equipment and landing of aircraft (helicopter sling delivery). These are long-term recurring impacts that have the potential to affect dozens of visitors during each occurrence. However, flights will be scheduled to avoid peak visitation, and the new sites will not be encountered by the majority of wilderness users.

The Mount Rainier Wilderness is uniquely influenced by its volcanic and glacial features, which include inherent hazards that have the potential to affect wilderness users, park administrative sites, and downstream communities within 10 to 20 minutes of initiation. These events range from frequent local-scale events to rare regional-scale events. Alternative 4 is the minimum necessary to detect, monitor, and study these events within the short time frames required, and with the accuracy necessary to inform emergency response.

Mitigation measures are found in Appendix A of the EA.

References

National Park Service (NPS) 2017. Wilderness Basics. Mount Rainier National Park. Eve S. Barnett. Winter 2016-2017.

Approvals

Which of the prohibited uses found in Section 4(c) of the Wilderness Act are approved in the recommended alternative and for what quantity?

Approved?	Prohibited Use	Quantity
☐	Mechanical Transport:	
☒	Motorized Equipment:	Portable electric and gas-powered hand tools for installation; motorized hand tools for periodic maintenance
☐	Motor Vehicles:	
☐	Motorboats:	
☒	Landing of Aircraft:	Up to 8 flights involving helicopter landing for installation and 4 maintenance flights involving helicopter landing every 5 years per site
☐	Temporary Roads:	
☐	Structures:	
☒	Installations:	5 new monitoring stations, 1 upgraded monitoring station.

Record and report any authorizations of Wilderness Act Section 4(c) prohibited uses according to agency policies or guidance.

Refer to agency policies for the following signature authorities:

Prepared:

Name DANIEL VAN DER ELST Digitally signed by DANIEL VAN DER ELST Date: 2022.03.24 14:28:36 -07'00' Position

Signature _____ Date _____

Recommended:

Name DANIEL VAN DER ELST Digitally signed by DANIEL VAN DER ELST Date: 2022.03.24 14:23:50 -07'00' Position

Signature _____ Date _____

Recommended:

Name TERESA TUCKER Digitally signed by TERESA TUCKER Date: 2022.03.24 14:33:41 -07'00' Position

Signature _____ Date _____

Approved:

Name Position

Signature _____ Date _____

Attachment A
Description and Rationale for Power Tool Use