Attachment A: Errata

Lahar Detection System Environmental Assessment

Mount Rainier National Park

March 2022

Edits to the Environmental Assessment

This Errata indicates changes made after public and agency review of the Lahar Detection System Environmental Assessment (EA).

The following is incorporated through these errata in the EA as noted below:

Page 23, Alternatives Considered but Dismissed – the following alternatives are added to the list of alternatives considered but dismissed.

Locate All New Lahar Detection Installations Outside Wilderness

Because the intent of the proposed project 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, placing the stations outside wilderness would mean locating them at a greater distance from the volcano. This would not meet the purpose and need for the project because locating stations at a greater distance from the volcano would not achieve the goal of rapidly detecting debris flows and lahars to provide authorities inside and outside the park with as much time as possible to notify and potentially evacuate residents, staff, and visitors.

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 in designated wilderness at Mount Rainier.

The effects of installing all new long-term lahar detection installations outside of wilderness is

described in the No Action Alternative (Alternative 2).

Increase the Number of Stations Proposed by the USGS

Additional stations would need to be installed by the USGS inside the park to enable robust lahar detection capabilities in other parts of the park besides the Nisqually River drainage, including the Carbon, White (East and West Forks), Muddy Fork of the Cowlitz, and Ohanapecosh River drainages. To enable robust lahar detection capabilities for all of Mount Rainier, the USGS would need to install three to four stations inside the park along each of these drainages, as well as additional high-elevation sites to serve as telemetry repeaters. Most sites would need to be near rivers and would feature a seismometer, an infrasound sensor and/or infrasound array, and in some cases a 300-foot- to 500-foot-long tripwire array. In addition, to bring the Mount Rainier volcano monitoring network up to the USGS's Level 4 standard for Very High Threat volcanoes, at least six additional GPS stations would need to be installed inside the park. In most cases, these GPS stations would not be collocated with the lahar detection sites as GPS stations need a clear sky view, which means the stations would need to be installed on ridgetops or other locations with few or no trees. This would translate to roughly 25 new lahar detection sites inside the park (i.e., 13 sites in addition to the 12 sites proposed in Alternative 1, the USGS Proposed Action).

Additional sites were not carried forward for further analysis because (a) current scientific understanding is that these other drainages are not as vulnerable to spontaneous noneruptive 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 under this alternative. As described in Appendix B of the EA, the primary risk scenario that has informed the design of the proposed lahar detection system expansion is a spontaneous (i.e., not associated with eruptive activity) collapse of a part of the west flank (Sunset Amphitheater), which has been shown by several studies to be the weakest flank of Mount Rainier and most susceptible to a spontaneous collapse.

Consider Alternative Technologies or Equipment to the USGS Proposed Action

The USGS considered several technologies and types of equipment other than those described in Alternative 1 – USGS Proposed Action. The USGS determined that no other technologies exist that would obtain the same data as the monitoring stations proposed or the impacts would be much greater that what is proposed. As such, these monitoring stations represent the best available technology to monitor volcanic activity and detect lahars and represent the minimum tools necessary to accomplish project objectives. Alternative technologies and equipment options described below were suggested during public review of the EA. Details regarding the reason for dismissing them from further analysis are included.

Use Drones for Equipment Installation and/or Remote Monitoring

Although unoccupied aircraft systems, or drones, have advanced in their capabilities, they would not be a suitable replacement for helicopters for this project due to the weight of the monitoring equipment, which is too heavy to be transported using drones. The use of drones instead of helicopters is technically infeasible and was not carried forward for further analysis.

Use Other Types of Remote Sensing, Monitoring, and Transmission

In addition to the use of drones, several remote technologies other than those described in Alternative 1 – USGS Proposed Action were considered, such as infrared cameras, lidar, radar, and satellite imagery. The USGS determined that no other technologies are available that obtain the same lahar detection data in the timeframe that is needed (seconds) to provide rapid detection and early warning of these hazards. In addition, such technologies cannot detect small-scale surface deformation and/or seismic activity that might precede a lahar-generating event. Technologies such as radar were dismissed because of the power requirements and large footprint needed for batteries and solar panels (see EA Appendix B). As such, the USGS-proposed monitoring stations represent the best available technology to monitor lahar activity. The use of other types of remote sensing, monitoring, and transmission equipment would not meet the purpose and need for the project and were not carried forward for further analysis.

Repurposing of Existing Monitoring Station Equipment Instead of Installing New Stations

The USGS considered numerous locations for monitoring the drainages most vulnerable to lahars produced by a spontaneous landslide stemming from the west flank of Mount Rainier. The existing monitoring stations do not provide the data needed for rapid lahar detection and warning for all vulnerable drainages (see EA Appendix B). The NPS determined that the locations provided by the USGS are the optimal locations to obtain the data necessary for the system. Use of the existing monitoring equipment to meet the objectives of lahar detection without placing new equipment in targeted drainages is infeasible and was not carried forward for further analysis.

Temporary and Portable Equipment Instead of Proposed Year-Round Installations

The USGS considered temporary placement of seismic monitoring equipment; however, temporary placement of equipment would not achieve the purpose of continuous year-round monitoring that is needed to provide rapid detection and early warning of a large lahar. Temporary monitoring stations do not transmit data in real time, are not continuous, and are only functional in the summer months. Temporary and portable equipment would not meet the purpose and need for the project and was not carried forward for further analysis.

Underground Station Siting

During the public comment period, it was suggested that all proposed equipment be located underground to minimize visual disturbance. Although some elements of the proposed lahar detection system are buried, it is not feasible to place all associated equipment underground. In addition to requiring greater ground disturbance and loss of vegetation, burial would be infeasible in several locations due to the presence of bedrock. It would also remain necessary to include solar panels and telemetry equipment aboveground to generate power and to transmit data. This option was not carried forward for further analysis due to infeasibility to meet the purpose and need of the lahar detection system.

Install New Stations in Wilderness Only in Locations with Existing or Previously Authorized Developments; Do Not Install New Stations in Undeveloped Wilderness

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 and Tahoma Vista), or near the large man-made suspension bridge across Tahoma Creek Bridge. 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 equipment would be installed at up to nine sites in the park, of which six 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 Lookout) would not repeat data from any current or proposed stations. Because 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 be needed. If an alternate solution cannot be found for transmitting data from the Mount Wow site, then this alternative would eliminate 5 of the 12 proposed station installations in Alternative 1.

This alternative would have limited 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 eight to four or five, which would result in significant degradation in lahar detection capabilities in several ways, as described below, and would not meet the project purpose. Accordingly, this alternative was not carried forward for further analysis.

Reduced Infrasound Detection Capabilities

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 but are not included in this alternative). Emerald Ridge would likely be destroyed within one 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 reduction in infrasound-based lahar detection and flow-tracking capabilities. Infrasound waves, like other sound waves, are heavily impacted by topography. Because 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.

Reduced Ability to Detect Small Precursor Earthquakes

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)). These sites are not included in this proposal. 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. Because 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.

Reduced Timeliness and Reliability of Lahar Detections

Without Mildred Point, Copper Mountain, and Ararat South, the reliability and timeliness of seismic-based lahar detections would be significantly reduced. 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 would then 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 negatively impact 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 about 3 to 4 minutes after lahar initiation, leaving only about 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.

No Improvement in GPS-based Volcano Monitoring at Mount Rainier

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 represents the largest gap in the USGS's deformation 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 several 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 (e.g., running fiber optic cables up the Westside Road), or it would be unusable for real-time data. 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, power along with a fiber optic cable would need to be run up the Westside Road. Without the Mount Wow site, there would be additional 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 in the EA for a full description of the capabilities that would be enabled by the Mount Wow site).

The following section includes text changes to the EA. EA text to be deleted is shown as ~~red strikeout~~, and revised or new text is shown as *red italicized text*.

Page 21. Alternative Summary – Table 3, Summary of Alternatives

Table 3, Summary of Alternatives, is replaced by the table below. Helicopter flight revisions were made for the following reasons:

- The number of new sites requiring helicopter use initially included the upgraded site at Emerald Ridge. The proposed installation at Emerald Ridge would replace an existing site and would not be a new helicopter-dependent site.
- The helicopter flights for maintenance of existing sites includes 24 flights for seven existing stations, equaling 168 flights over 30 years.
- The helicopter flights for maintenance of new helicopter-dependent sites includes 27 flights for each new station, which varies by alternative, plus 3 tuning flights for the upgraded site at Emerald Ridge.

Table 1. Summary of All Alternatives.

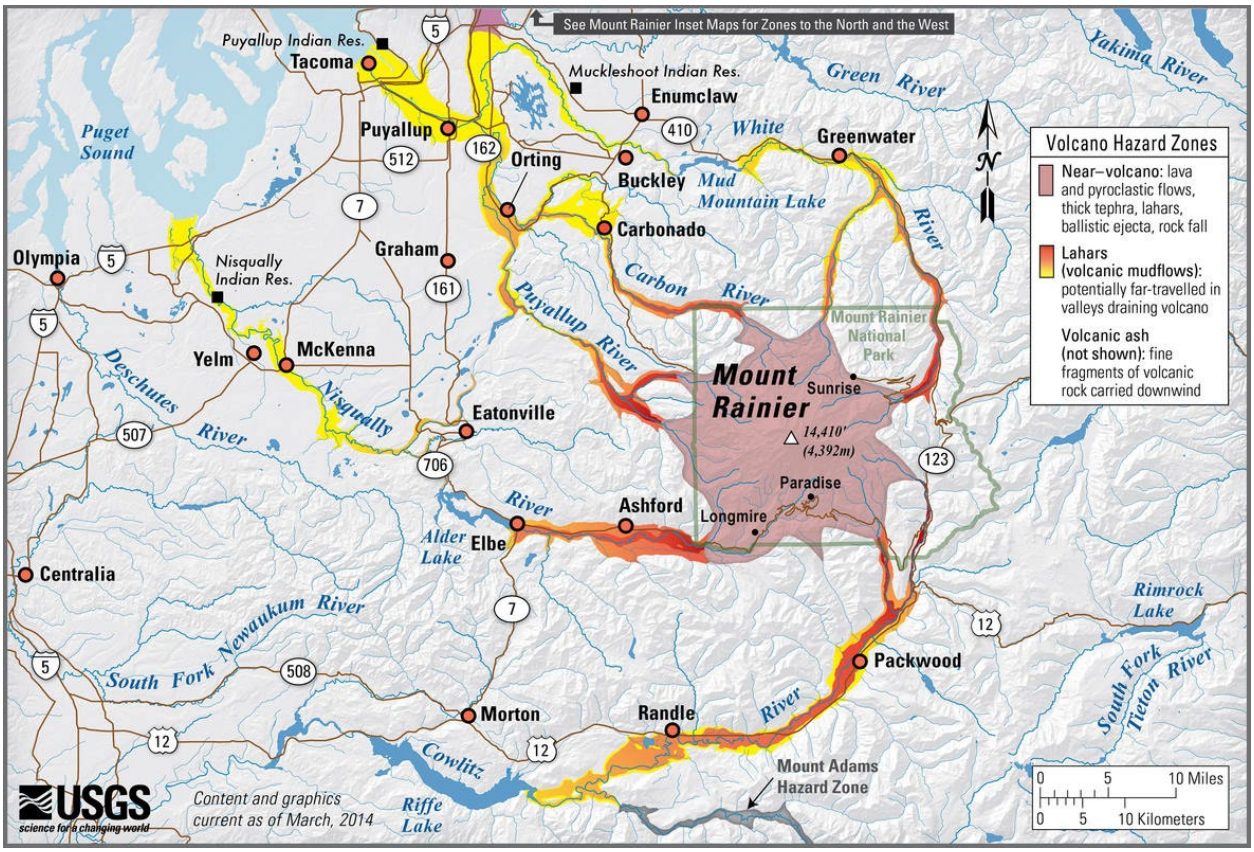
	Alternative 1 – USGS Proposed Action	Alternative 2 – No Action	Alternative 3 – Alternative Monitoring Sites	Alternative 4 – Reduced Number of Monitoring Sites (NPS Preferred Alternative)
Total of **new** monitoring stations proposed in MRNP	12	0	12	9
Total stations (**15 existing** stations plus new stations proposed in MRNP)	26	15	26	23
• **New sites** proposed in wilderness	9	0	11	6
• **Total sites** in wilderness (**5 existing plus new sites** proposed)	13	5	15	10
• **New sites** proposed in NHLD	6	0	1	3
○ Sites on/near MRNP historic structure	4	0	1	1
New sites requiring helicopter use	~~*8*~~**9**	0	*10*~~*11*~~	~~*5*~~**6**
Helicopter flights for maintenance of existing sites over 30 years (24 trips per site)[1] ~~Helicopter flights for maintenance of existing sites over 30 years (~24 trips per site)~~[1]	*168*	*168*	*168*	*168*
Helicopter trips for installation of new sites (*8 trips per site, including*~~7 trips per site, plus 1 trip per site for~~ revegetation)	72	0	88	48
Additional helicopter trips for tuning and maintenance of new sites over 30 years (27 trips per site)[2] ~~Additional helicopter trips for tuning and maintenance of new sites over 30 years (~27 trips per site)~~[2]	*219*	0	*273*	*138*

[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. *An additional three trips for tuning at the upgraded Emerald Ridge site are also included.*

Page 5. Alternative 1 – USGS Proposed Action

Revised text:
"….The remaining nine stations would be installed to increase rapid detection along the west flank of Mount Rainier, which is the most vulnerable to a large lahar down the Puyallup River, Mowich River, or Tahoma Creek drainage *(Figure 1)*." (*Note that all subsequent figures to be renumbered*).

In addition, add map below on page 6 of the EA, to provide context and geographically reference to the drainages of concern.



Page 10. Alternative 1 – USGS Proposed Action, Helicopter Use for Installation

Revised text:
Flight time would be about 1 to 2 hours per day at each site over a period of 2 days or about 32 to ~~63~~ *72* hours of flight time over about 18 to 22 days during installation over a 2-month period (September and October; excluding weekends) each year for 2 years.

Page 10. Alternative 1 – USGS Proposed Action, Helicopter Use for Maintenance

Revised text:
For example, under the USGS Proposed Action, about ~~243~~ *219* maintenance flights would be performed over a period of 30 years with about ~~122~~ *110* to ~~243~~ *219* hours of flight time for maintenance flights over a period of 30 years.

Page 15. Alternative 2 – No Action

Revised text:
The USGS would continue to monitor volcanic activity at the seismic and GPS monitoring sites listed above and would maintain these sites as needed. From 2009 to 2019, the USGS flew 47 total helicopter sling loads to six *aircraft-dependent* sites *(four 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 ~~six~~ *five* existing monitoring sites *in wilderness* that are helicopter dependent, for a total of about ~~144~~ *120* flights over 30 years.

Page 17. Alternative 4 – Reduced Number of Monitoring Sites (NPS Preferred Alternative)

Revised text:
Under the NPS Preferred Alternative, about ~~42~~ *48* flights would be needed for installation. About ~~189~~ *138* maintenance flights would be performed over a period of 30 years with about ~~95~~ *69* to ~~189~~ *138* hours of flight time for maintenance flights over a period of 30 years.

Page 32. Environmental Consequences, Alternative 2 – No Action, Special Status Species – Northern Spotted Owl and Marbled Murrelet

Revised text:
As previously described, the total number of flight hours in the park from 2015 to 2019 averaged 142 flight hours per year and the USGS estimates that about 3 to 4 maintenance trips per site would be needed every 5 years for the ~~six~~ *five* existing monitoring sites that are helicopter dependent, for a total of about ~~144~~ *120* helicopter flights over 30 years.

Page 33. Environmental Consequences, Alternative 3 – Alternative Monitoring Sites, Special Status Species – Marbled Murrelet

Revised text:
The impacts from helicopter flights would be the same as described for the USGS Proposed Action, except that medium helicopters would be needed for the Shriner Peak and Fremont Lookout alternative sites and the total number of helicopter flights would increase from 72 to about 88 during installation and increase from about ~~243~~ *219* to about ~~297~~ *273* for maintenance over a period of 30 years, an increase of about ~~22~~ *25* percent.

Page 34. Environmental Consequences, Alternative 4 – Reduced Number of Monitoring Sites (NPS Preferred Alternative), Special Status Species – Northern Spotted Owl

Revised text:
Helicopter flights would be the same as described for the USGS Proposed Action, except that the total number of helicopter flights would decrease to about 48 during installation over a 2-month period (September and October) each year for 2 years, and about ~~189~~ *138* maintenance flights over a period of 30 years.*

Page 34. Environmental Consequences, Alternative 4 – Reduced Number of Monitoring Sites (NPS Preferred Alternative), Special Status Species – Marbled Murrelet

Revised text:
The impacts from helicopter flights would be the same as described for the USGS Proposed Action, except that the total number of helicopter flights would decrease from 72 to about 48 during installation and decrease from about ~~243~~ *219* to about ~~189~~ *138* for maintenance over a period of 30 years, a decrease of about ~~22~~ *59* percent.

Page 39. Public Health and Safety – Affected Environment

Revised text:

However, in the Nisqually River drainage, *and* in particular the Tahoma Creek drainage, the time to nearest impact on *residential* population*s* is estimated by recent modeling studies to be as little as 10 to 20 minutes (George et al. ~~in review~~ *in press*); thus, enhanced monitoring high in the drainage (and in the park) is required to mitigate the hazard. ~~Most lahar at Mount Rainier and around the world are linked with eruptions at the volcano.~~

In a 2008 report, a panel of scientists issued a recommendation that Very High Threat volcanoes like Mount Rainier have 12 to 20 seismic and GPS stations within 20 kilometers *in order* to effectively monitor unrest at the volcano (Moran et al., 2008).

Page 47. Environmental Consequences, Alternative 1 – USGS Proposed Action, Wilderness Character

Revised text:
The total number of helicopter flights would be about 72 during installation over a 2-month period (which would occur September and October 2021 and possibly extend into September or October 2022 depending on weather conditions and other factors) and about ~~243~~ *219* maintenance flights over a period of 30 years.

Page 48. Environmental Consequences, Alternative 1 – USGS Proposed Action, Wilderness Character

Revised text:
These effects would vary among individuals, depending on where visitors encountered the helicopter use, and would be temporary, limited to about ~~63~~ *72* trips during installation of nine sites over a 2-month period (September and October) in 2021 (possibly extending into September or October 2022 if weather or other conditions do not allow for completion of installations in 2021) and about ~~243~~ *219* maintenance flights over a period of 30 years.

Pages 50-51. Environmental Consequences, Alternative 2 – No Action, Wilderness Character

Revised text:
No new prohibited uses under the Wilderness Act would be proposed under the No Action Alternative and no new impacts on wilderness qualities would occur, although aviation-dependent sites would continue to require use of helicopters for an estimated ~~144~~ *120* maintenance flights over 30 years, as described under the description of the No Action Alternative above and in the Wilderness Minimum Requirements Worksheet (Appendix E).

Page 51. Environmental Consequences, Alternative 3 – Alternative Monitoring Sites, Wilderness Character

Revised text:
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 2-month period (September and October) and about ~~297~~ *273* maintenance flights over a period of 30 years (54 more than the USGS Proposed Action).

Page 52. Environmental Consequences, Alternative 3 – Alternative Monitoring Sites,

Wilderness Character

Revised text:
Helicopter use would be greater under Alternative 3 than under the USGS Proposed Action, increasing to 88 trips during installation and about ~~297~~ *273* maintenance flights over a period of 30 years.

Page 54. Environmental Consequences, Alternative 4 – Reduced Number of Monitoring Sites (NPS Preferred Alternative), Wilderness Character

Revised text:
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 ~~189~~ *138* maintenance flights over a period of 30 years (54 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 3 to 6 percent in flight time compared to the existing number of flights over the 30-year maintenance period.

Page 55. Environmental Consequences, Alternative 4 – Alternative Monitoring Sites, Reduced Number of Monitoring Sites (NPS Preferred Alternative), Wilderness Character

Revised text:
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) each year for 2 years (including up to 6 flights for revegetation), and about ~~189~~ *138* maintenance flights over a period of 30 years.

Page 58. REFERENCES

Revised text:
George, D.L., R.M. Iverson, and C. Cannon (~~in review~~ *in press*). Modeling the dynamics of lahars that originate as landslides on the west side of Mount Rainier, Washington: Preliminary results. ~~USGS~~ *U.S. Geological Survey* Open-File Report *2021-1118*.