Wildfire-associated Landslide Emergency Response Team (WaLERT) Report for the Left Hand Fire

Naches Ranger District—Okanogan–Wenatchee National Forest, Washington

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Introduction

A rapid Wildfire-associated Landslide Emergency Response Team (WaLERT) assessment was conducted to evaluate the hazard posed to the public by landslides and debris flows from the Left Hand Fire. Wildfire can significantly change the hydrologic response of a watershed, to the extent that even modest rainstorms can produce dangerous flash floods and debris flows.

WaLERT assessed areas downstream of slopes burned by wildfire to determine whether landslides or debris flows could reach highways, buildings and structures, or other areas where public safety is a concern. In cases where the team could not identify debris flow or landslide hazards, flash flood hazards were assessed. Further information about these hazards is provided in Appendix A.

WaLERT looked for historical evidence of debris flows using field reconnaissance, interpretation of lidar, Burned Area Reflectance Classification (BARC) maps, and orthoimagery. Local knowledge of past flooding and wildfire-associated erosional events from residents and forest service workers also informed the team's assessment. WaLERT performed field observations to evaluate the characteristics of surficial deposits, hillslope conditions, and channel bed material, gradient, and confinement. Although we briefly discuss soil burn severity, a more detailed description of fire effect on soils and hydrology can be found in the related narratives in the U.S. Forest Service Burned Area Emergency Response (BAER) report.

This report is a qualitative assessment of post-wildfire hazards based on our professional judgment and experience and was performed as part of an emergency response, with the intent to produce a rapid report for decision-makers, land managers, land owners, and other stakeholders. It was carried out at the request of and in cooperation with the U.S. Forest Service, Okanogan—Wenatchee National Forest BAER team.

Wildfire overview

The Left Hand Fire was ignited by lightning on July 23, 2019, 32 mi northwest of Yakima, Washington in the Okanogan–Wenatchee National Forest (Fig. 1). The fire burned in steep, rocky terrain with difficult access. To date, the fire has burned 3,406 acres north of State Route (SR) 410, near Pinecliff.

Observations and interpretations

Field assessments were performed on August 12 and 13 and focused on areas where the effects of wildfire on watershed hydrology could put life and property at risk. These areas are downstream of the fire perimeter in two areas: where Rock Creek passes under SR410 and at the confluence of Left Hand Fork and Right Hand Fork Rock Creek. SR410 is approximately 1.2 mi downstream of the southern fire perimeter and the first residence is approximately 0.5 mi downstream of the southern fire perimeter. Rock Creek passes under SR410 at milepost 102.3. The confluence of Left Hand Fork and Right Hand Fork Rock Creek is 550 ft downstream of the southern fire perimeter.

Rock Creek at SR410 milepost 102.3

Observations

The Left Hand Fire burned approximately 30 percent of the Rock Creek basin (Fig. 1); however much of the burned area was of low soil burn severity based on the findings of the U.S. Forest Service BAER team (Table 1).

Table 1. Soil burn severity by area and percent of total burned area.

Soil Burn Severity	Acres	Percent of Burned Area
High	2	<0.1
Moderate	96	2.8
Low	2,094	61.4
Unburned soil	800	23.5
Unclassified (for example, rock slopes without soil or vegetation)	420	12.3
Total	3,412	100

Accounts from local residents suggest that Rock Creek has suffered flood events at least as recently as 1996 and 2011. We observed sandbags, straw bales, and berms downstream of SR410 where Rock Creek passes between two residences before turning south and passing between the levee at the Naches River and six additional homes (Fig. 2, Site 1; Figs. 3, 4, and 5). Residents told us that three of these homes had flooding problems in the 2011 flood event with at least one home condemned due to flooding. We observed two vacant homes on the downstream side of SR410, associated with damage due to the 2011 flood event.

Where Rock Creek flows under SR410, the creek is confined to a box culvert approximately five ft across. The channel appears to have been recently cleared of rocks and debris on the upstream side. Piles of straw and yard waste extend along the north side of the upstream culvert wall.

Upstream of SR410 the channel is confined by a berm along Rock Creek Road (FS1702) where the road ascends an older alluvial fan. Topped by this berm, the channel walls extend vertically 6–12 ft from the channel bottom, and the berm extends at least 300 ft upstream from the SR410 culvert (Fig. 2, Site 2). The berm appears to have been repaired within the past five years. Along with road surface damage and piles of woody debris, the berm repairs suggest that the channel has recently flooded the road along this stretch.

Interpretations

We interpret the fan at the mouth of Rock Creek to be a prehistoric (pre-1850) relict fan based on its elevation above the Naches River floodplain. The incised channels cut into the fan date back to at least 1899 (visible on a historical topographic map). From the 1899 map, we infer that the toe of the Rock Creek relict fan was already eroded away by the Naches River. Since that time, there has been little or no fan regrowth.

While the Rock Creek channel has been anthropogenically modified, we did not observe abundant modern fan deposits, suggesting that historical flood events may not be depositing large enough volumes of material at the mouth of Rock Creek to form a modern fan. New deposition at the mouths of the two channels incised into the older Rock Creek relict fan forms modern fan deposits, each less than one acre in size.

Rock Creek, from SR410 to the confluence of Left Hand and Right Hand Forks

Observations

Upstream from the SR410 box culvert, we observed two culverts on Rock Creek (Fig. 2 , Sites 3 and 5) and one culvert on Right Hand Fork Rock Creek immediately above its confluence with Left Hand Fork Rock Creek. These metal culverts are all approximately four ft in diameter or less. There is also a cement girder residential bridge over Rock Creek (Fig. 2, Site 4). These culverts and bridges all lie downstream of the Left Hand burned area.

At each culvert there is evidence of past flooding damage. This evidence is in the form of piled woody debris, stream boulders carried as bedload, damage to metal culverts from boulder impacts (Fig. 6), and signs of efforts to manage floodwaters that topped the road when the culverts clogged or did not have the capacity to carry floodwater. Signs of floodwater mitigation efforts are ditches around the culvert area and small boulder berms. A resident informed us that the residential driveway bridge (Site 4) had been raised a few feet to allow more freeboard for floodwater flow.

On the stream reach from SR410 to the confluence of Right Hand and Left Hand Fork Rock Creek, the stream bank is locally armored with boulders to protect house pads. It is unclear whether the dry old channel to the south of the active Rock Creek channel lacks flow due to stream modification or due to natural avulsion (Fig. 2). The current channel is shown as active on the 1899 topographic map.

We observed stream deposits along Right Hand Fork Rock Creek and an unnamed branch of Rock Creek that we refer to as Middle Fork Rock Creek (Fig. 1). Middle Fork joins Right Hand Fork approximately 800 feet upstream from the confluence of Right Hand Fork and Left Hand Fork. The Middle Fork catchment basin lies nearly completely within the Left Hand Fire burned area. Most of Right Hand Fork Rock Creek lies within the burned area of the 2016 Rock Creek Fire. We sought evidence of debris flows in the lower unburned catchment of Right Hand Fork Rock Creek. Both Middle Fork and Right Hand Fork show evidence of flooding but no evidence of debris flows.

Interpretations

This area appears to be susceptible to flooding during rain-on-snow events and has the potential for additional flooding after the Left Hand Fire. We did not observe debris flow deposits. Instead it appears that the lower reaches of Rock Creek suffer periodic flooding unrelated to wildfire.

The 2016 Rock Creek Fire, which burned in the Right Hand basin, had a higher burn severity than the Left Hand Fire. If debris flows have initiated in the Right Hand basin in the last three years, none of them have mobilized to the confluence of Right Hand Fork and Left Hand Fork Rock Creek. After the Left Hand Fire, we do not expect that debris flows will mobilize from the Left Hand basin to reach life and property downstream. However, all three forks of Rock Creek show evidence of flooding and may be at risk of additional flooding during heavy precipitation events. The dry old channel to the south of the active Rock Creek channel may capture floodwaters during such an event, and there is no culvert in position where the dry channel meets SR410.

Due to the low percentage of high and moderate soil burn severity from the fire and the lack of obvious past debris flow deposits and alluvial fan activity, we did not request that the U.S. Geological Survey run a Post-Fire Debris Flow Hazard Assesment.

Recommendations

Our assessment suggests that flooding is the hazard most likely to impact the areas we evaluated. The low likelihood of debris flows in the inhabited area is primarily due to (1) these areas being far enough downstream that upper basin debris flows attenuate before reaching the inhabited area; and (2) the basin having experienced low burn severity. However, evidence from past events indicates that floodwater and flood-borne debris are a hazard to people and property along Rock Creek regardless of the effects of wildfire.

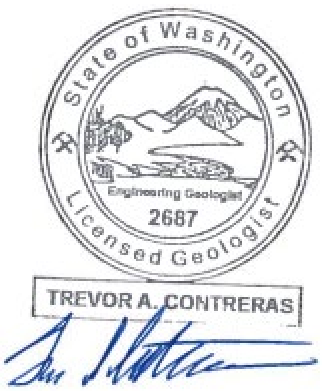
The most significant potential impact at all visited sites is flash flooding and associated damage by impact from debris, sedimentation, water erosion, and (or) water inundation. Residents of cabins and homes built on alluvial fans and (or) adjacent to streams flowing from burned areas should be informed of potential post-fire flash flooding hazards. Managers of transportation networks such as counties, WSDOT, and FHWA should be reminded of the increased likelihood of sediment transport, sediment deposition, and (or) erosion to highways/roads, as well as potential issues with blocked culverts. We suggest reminding transportation network managers to inspect culverts from channels draining areas impacted by the fires before and after storm events.

Areas of specific concern:

- Rock Creek (MP 102.3) passes under SR410 through a five-ft box culvert that conveys water under the highway and between two homes. A flash flood event magnified by hydrophobic soil conditions could mobilize large volumes of woody debris that could block the intake of the box culvert, potentially impacting the state highway. We recommend providing WSDOT with hydrological modeling for Rock Creek from the U.S. Forest Service BAER report. The box culvert could be impacted and needs additional maintenance. Additionally, if the channel is impacted by debris above the culvert under Rock Creek Road (Fig. 2, Site 3), water could migrate to the south and use the abandoned old channel, flooding the area east of SR410.
- Property owners along Rock Creek should be notified of the increased flood hazard during heavy precipitation events and rain-on-snow events and may consider talking with their insurers about flood insurance coverage. They may need to plan for evacuation depending on flooding.
- Culverts and the bridge along Rock Creek could become plugged during heavy precipitation events and exacerbate flooding downstream. Land managers and landowners should consider additional monitoring and maintenance of culverts.

Limitations

WaLERT aims to quickly identify and assess geologic hazards associated with wildfires in order to inform decision making and to help focus the efforts of local officials and residents who may be impacted by post-wildfire hazards. All observations and interpretations are based on empirical evidence and local knowledge. Not all areas or hazards were evaluated and no debris flow modeling was performed. We encourage landowners, land managers, and those potentially at risk from post-wildfire hazards to consult qualified professionals for site-specific analysis of geological hazards and flood risk.



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Appendix A: Geological background

Hillslope processes

A variety of factors contribute to the probability of debris flows occurring in burned areas. These include hillslope gradient, channel convergence, availability of fine sediments, severity of hydrophobic (water repellant) soil conditions, burn severity, and the removal of a protective canopy and diminished root strength caused by fire.

Hydrophobic soil conditions in burned areas can increase water runoff potential on hillslopes during a storm by preventing water from infiltrating into the subsurface. Overland flow can result in rills and gullies that further channel water downhill.

When effective ground cover has been denuded after intense fire, soils are also exposed to erosive forces such as raindrop impact and wind. The steepest slopes are most prone to erosion, particularly where soils are shallow or where there is a restrictive subsurface layer such as bedrock. Soils that have developed in volcanic ash and glacial till are easily detachable, having low cohesion and structure, and contain relatively low amounts of organics, resulting in moderately thin topsoil horizons.

Flash floods and debris flows

Debris flows have a specific geologic definition that is often misused by the media, the public, and scientists. Most observed "debris flows" are actually sediment-laden flash floods or "hyperconcentrated flows." In the following sections, we explain the differences between these two types of flows.

Flash floods

Flash floods, especially those that originate from recently burned areas, are often described as "debris flows" due to the appearance of sediment-laden water transporting woody and vegetative debris, trash, gravel, cobbles, and occasionally boulders. Though "debris flow" may be an observer's description of the event, a true debris flow has specific properties, behaviors, and characteristics that significantly differentiate them from flash floods. What are often described as "debris flows" are actually sediment-rich flash floods called hyperconcentrated flows (HCFs). An HCF is the transition between a flash flood and a debris flow. One way geologists differentiate the three is by the percent of sediment (by volume) carried by the flowing water. A flood contains less than five percent sediment by volume, an HCF carries around five to 60 percent sediment by volume, and a debris flow exceeds 50 percent sediment by volume.

Debris flows

Debris flows are often described as having the appearance of flowing, wet concrete. These flows travel quickly in steep, convergent channels. A moving debris flow can be very loud because it can buoy cobbles, boulders, and debris to the front and sides of the flow. The sound is often compared to that of a freight train and may cause the ground to vibrate. In a post-fire situation, a debris flow may start as a flash flood surge that entrains (picks up) sufficient sediment to transform into an HCF and, if soil and slope conditions are suitable, can transform into a debris flow.

Debris flow deposits tend to be distinct and include channel-adjacent levees of gravel, cobbles, and boulders. Channel-adjacent trees display upslope damage such as scarring on bark from rock or debris impact. Mud and gravel may be splashed onto trees and other channel-adjacent objects. Because of the ability of a debris flow to buoy these materials to the front of the moving mass, debris flows are extremely dangerous to public safety and infrastructure.

Alluvial fans

Alluvial fans are low-gradient, cone-shaped deposits that consist of sediment and debris. These features often accumulate immediately below a significant change in channel gradient and (or) valley confinement. This might occur at the mouth of a canyon or steep channel that drains from mountainous terrain and emerges onto a low gradient area such as a flood plain. Sediment on the alluvial fan is deposited by streams, floods, HCFs, and (or) debris flows and is typically sourced from a single channel.

Alluvial fans are attractive locations to build cabins and homes due to the slight elevation above the flood plain. However, alluvial fans are active depositional areas that accumulate sediment over time. The sediment can be deposited both slowly, such as during a spring melt when high streamflow during spring runoff transports and deposits fine sediment on the fan, or quickly, when a flash flood, HCF, or debris flow transports sediment and debris to the fan.

Figures

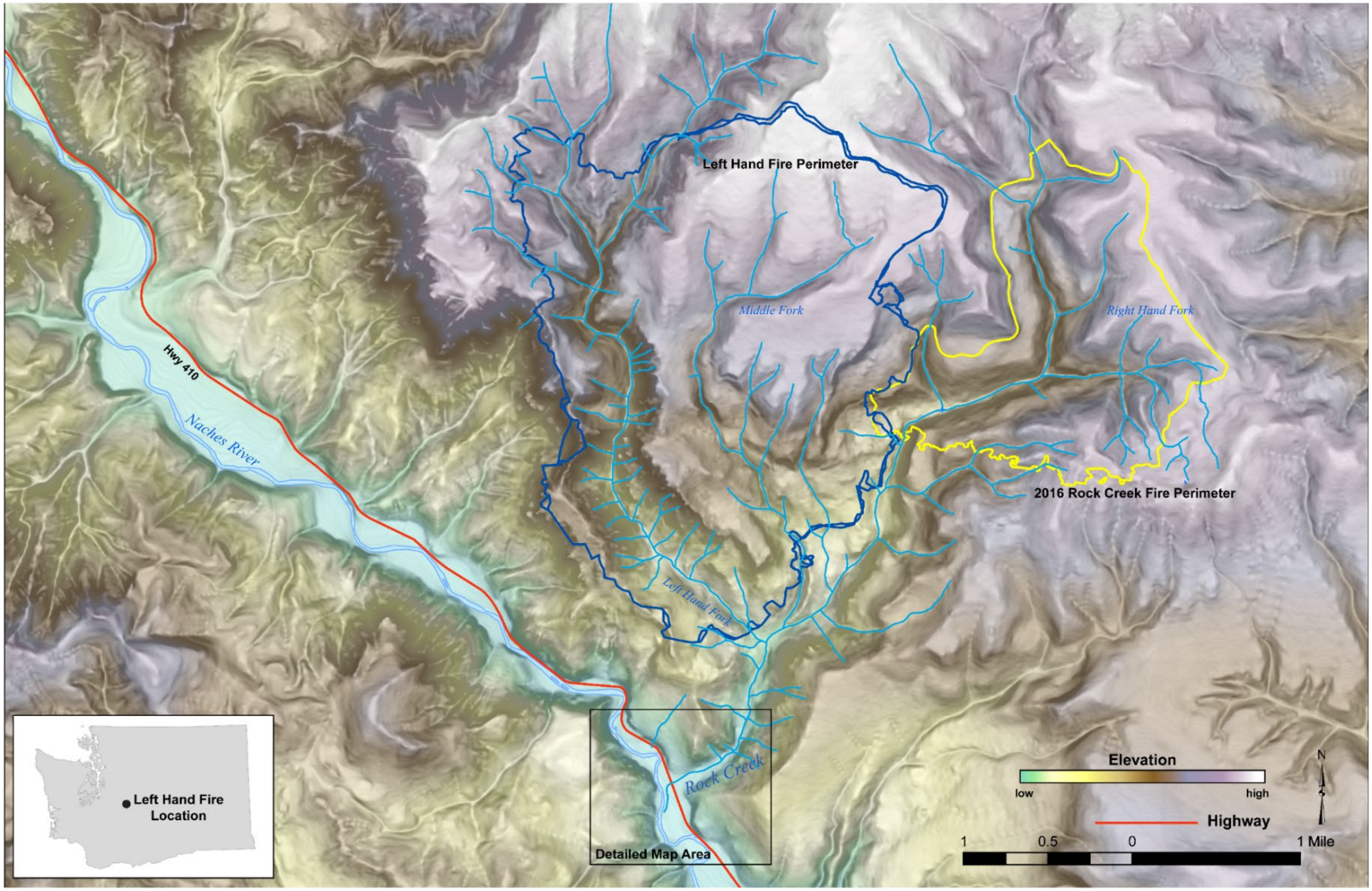

Figure 1. Left Hand Fire location, showing 2019 Left Hand Fire burned area perimeter on Left Hand Fork Rock Creek and the informally named Middle Fork Rock Creek. Also shown is the 2016 Rock Creek Fire burned area perimeter on Right Hand Fork Rock Creek.

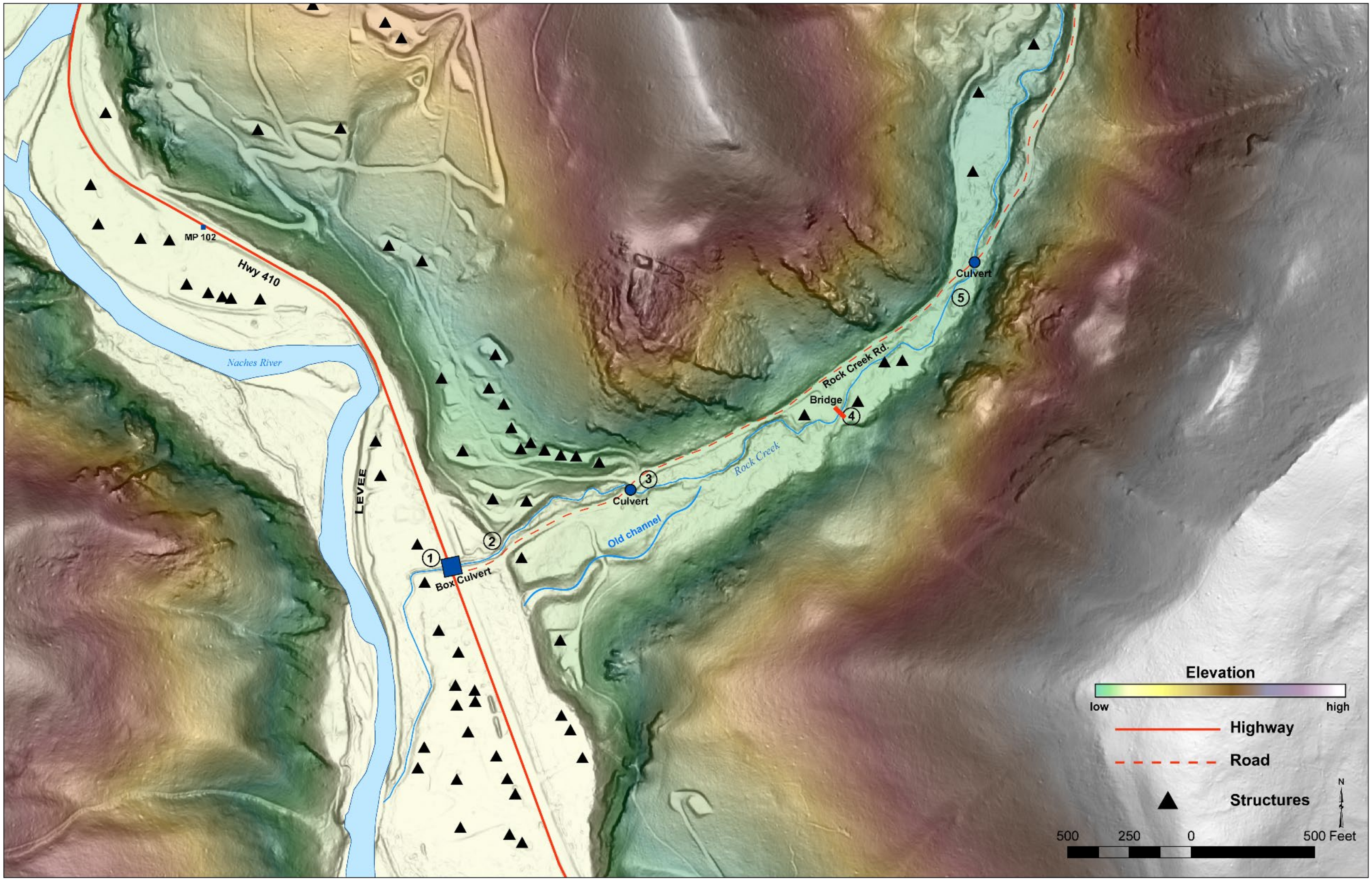

Figure 2. Rock Creek downstream of the Left Hand Fire, where the creek enters the Naches River. Site numbers refer to sites discussed in report. Black triangles indicate the locations of structures taken from Bing Maps team data. Rock Creek was digitized from lidar and limited field observations.

Figure 3. Box culvert at SR410, looking west toward homes 14710 and 14680 WA-410. Site 1 on Figure 2.

Figure 4. Home at 14680 WA-410, downstream of box culvert along Rock Creek. Note sandbags, boulders, and damage to the base of the tree trunk, second from right, as evidence for previous flooding events. Site 1 on Figure 2.

Figure 5. Home at 14710 WA-410 downstream of box culvert under SR410 along Rock Creek. Note berm built to protect house. Site 1 on Figure 2.

Figure 6. Site 5 on Figure 2, showing culvert under Rock Creek Road. Note bent and torn metal culvert edges from flood-borne rock impacts. Blockage of this culvert could divert the creek, blocking and damaging the road.