Site and Reach Assessment
Nason Creek
at SR207 MP 0.4, 0.65, 0.9

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Summary

Report findings:

- A 1.5 mile stretch of state route 207 (SR207) is threatened by erosion from Nason Creek There have been multiple episodes or repair, resulting in ad hoc protection of the highway.
- The highway was re-aligned in 1941, being relocated from the foot of Natapoc Ridge to the middle of the floodplain of Nason Creek. This cut off flow and interaction with parts of the east side of the floodplain, and it has caused the stream to impinge on the road prism.
- In the reach underneath Bonneville Power Administration (BPA) power lines, wood debris has come and gone, creating a side channel but also preventing some of the flow entering from the main channel.
- Under the BPA power lines, riparian vegetation that would normally provide root strength to stream banks has been cleared to maintain the powerlines. This may be a contributing factor in channel instability at this location.

Report recommendations:

- We recommend a collaboration with the Yakama Nation to restore and/or enhance aquatic habitat in this reach of Nason Creek, while WSDOT implements measures that minimize the need for future emergency repairs, which typically result in degraded habitat.
- Proposed construction actions include adding large wood in flow deflecting engineered logjams (ELJs), and excavating portions of the floodplain to reconnect side channels, add complexity and decrease flood water surface elevations.
- The project reach was divided into three areas, due to its size.
    - Area 1: Reconstruct existing barbs to incorporate large wood; secure existing wood with wood piles; install six bank-based ELJs using wood piles to secure them.
    - Area 2: Install multi-log, bank-based ELJs that are secured using wood piles and racking logs with rootwads between them. Excavate a high-flow channel into the sediment plug in front of the existing logjam. Install a rock and log toe in the area adjacent to the existing logjam on the right bank. Install two bank-based ELJs downstream of the log and rock toe, and a mid-channel-type ELJ.
    - Area 3: Excavate a side channel on the west side of the floodplain using one of two potential alignments that take advantage of old side channel topography. Install four bank-based ELJs, a log-and-rock-toe revetment, and one mid-channel ELJ.

1.0 Introduction & Methods

State Route 207 (SR207) runs through the Nason Creek Valley between Cole's Corner and Lake Wenatchee State Park, a distance of about 5 miles. Nason Creek impinges SR207 in several places (Figure 1), and threats to the highway have warranted the use of riprap to prevent further migration into the highway on a more frequent basis than three times in the past 10 years.

This site and reach assessment summarizes the existing information on the site, as it has been studied extensively by Chelan County and the Bureau of Reclamation. We then present several treatment options that protect SR207, and recommend a solution that provides an improvement in habitat function in Nason Creek, is self-sustaining, and requires little to no maintenance.

Methods

This study included literature and data review, field reconnaissance, and synthesis of relevant data. Sources of information include:

- Aerial photographs
- Ground photos obtained by Hydrology staff during site visits.
- LIDAR topographic data from 2007 and 2015
- GIS coverages of 24K USGS topographic maps, soils, and geology for this area.
- Fish distribution information available from the Washington Lakes and Rivers Information System (WLRIS).
- Engineering records from WSDOT headquarters.
- Existing literature and data, as listed in the "References" section of this report.

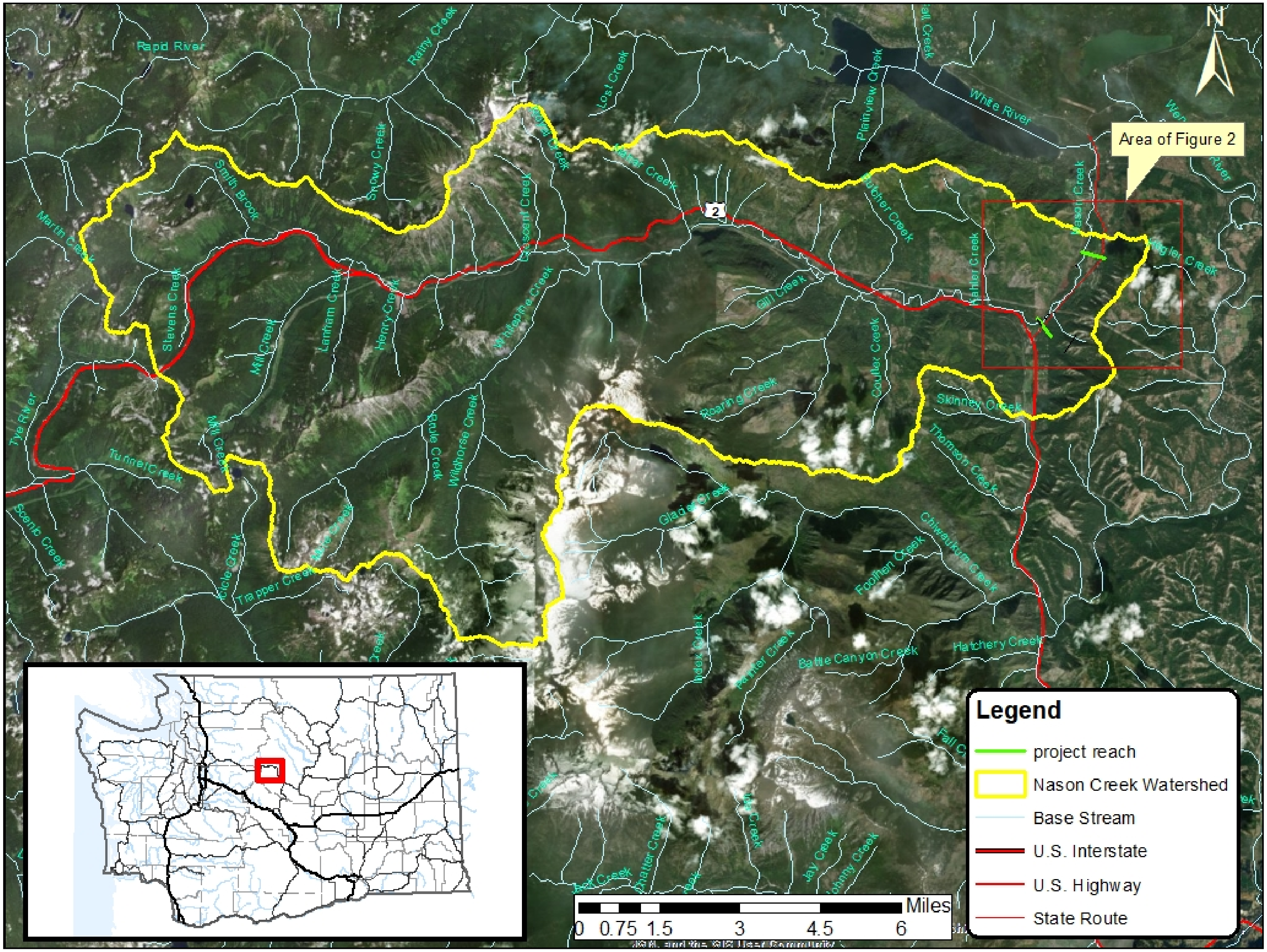

Figure 1. Project location map

2.0 Site Assessment

Washington State Department of Transportation (WSDOT) manages State Route (SR) 207 from Coles Corner to the intersection with Chiwawa Loop Road in Chelan County, Washington (Figure 2). SR 207 provides access to Lake Wenatchee state park, which is one of the most popular state parks in Washington in terms of the number of visitors per year. SR 207 is a two-lane rural collector highway with 12-foot wide lanes and 6-foot wide shoulders in the vicinity. The posted speed is 55 MPH with an average annual daily traffic of 2,000 vehicles. SR 207 also serves as the detour route when SR 2 is closed through Tumwater canyon. The SR 207 detour connects travelers from Stevens Pass to Leavenworth through Plain via the Beaver Valley road and Chumstick Highway.

Prior to 1941, SR 207 was called Secondary State Highway 15C (SSH 15C) and was located on the hillside east of the current alignment (See Figure 2). It was relocated to accommodate traffic at 60 miles per hour (WSDOT memoranda 1964 a-e). The former alignment is now US Forest Service roads 6603 and 6604.

For the purposes of this discussion, the project reach (see Figure 2) is divided into three areas (Figure 2).

Area 1

When the new alignment of SR 207 was constructed, Nason Creek was nearly 100 feet away from the highway prism at this location. In November 1995, a flood event on Nason Creek washed out a portion of SR 207 approximately ½ mile from the intersection with SR 2 at Coles Corner (Milepost 0.36 to 0.40; Figure 3). WSDOT repaired the highway in 1995 and installed riprap along the banks of Nason Creek. The emergency highway repair was constructed during high-water conditions and the toe of the slope wasn’t constructed below the potential scour depth. Additional riprap was later added to repair additional scouring along the base of the highway riprap protection. This second repair did not fix the toe of slope or the limited width of the highway shoulder (Figure 4). In 2011, WSDOT maintenance crews installed additional riprap to reinforce the toe of slope and slightly expand the width of the bank protection to create a 5-foot wide highway shoulder consistent with highway safety standards. This project also included the installation of four rock barbs to help deflect stream flows away from the highway prism (Figure 5).

The rock barbs have been effective at diverting flow from the base of the road prism. However, they have been deformed significantly from various flood events and are losing their effectiveness (Figure 6). Some wood has racked on the rock/barb structure at the upstream end, and has held in place for several years.

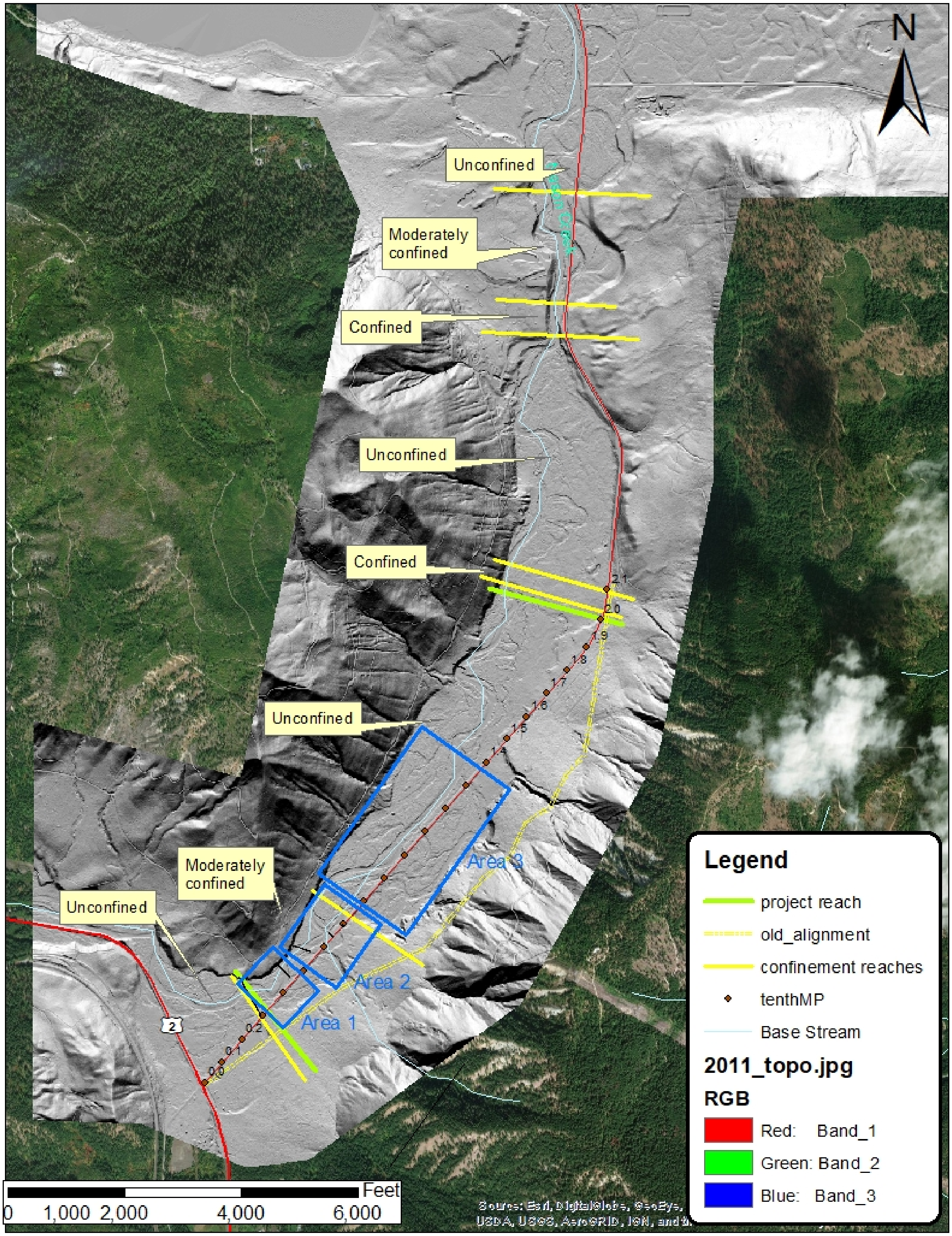

Figure 2. Lower Nason Creek and the project reach. (2015 LiDAR background).

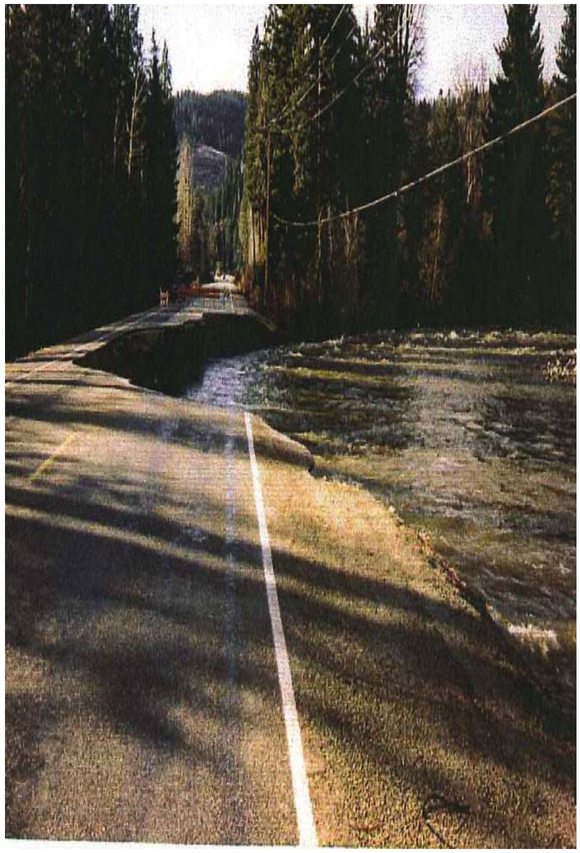

Figure 3. Area 1 erosion from 1995 flood.

Figure 4. Riprap installed after 1995 flood, from 2010.

Figure 5. Site conditions in Area 1 in 2011, after addition of rock barbs.

Figure 6a. Area 1 rock barbs in April 2018.

Figure 6b. Rock barbs in Area 1, low flow, looking downstream (October 2018).

Area 2

Just downstream of Area 1, between MP 0.6 and 0.7, is another area of concern, which has been the most active recently. This site has been eroding in pulses since 2009. Much of the area lies underneath Bonneville Power Administration (BPA) power lines, where riparian vegetation has been cleared and kept low. A fill pad adjacent to the west side of the highway is a remnant of a log scale facility. This fill has been eroding episodically in part due to the sizeable logjam that has formed just off the creek's right bank. A major flood in 2009 eroded the fill pad rapidly (Figures 7 & 8). Cutting of trees along the bank may have exacerbated this problem. The bank was treated with riprap (2012) to inhibit further erosion of the fill pad. In spring of 2018, erosion occurred behind the rip rap (Figures 9 & 10).

The presence of wood at the logjam is transient, and mobility of wood depends on many factors. In 2011 (Figure 11) and in 2017, a logjam nearly spanned the channel. However, in fall of 2017, the creek broke through. Between April and June of 2018, a large tree that had just fallen in the creek earlier that spring, was transported to the upstream end of the logjam. The flow through the logjam is now highly occluded (Figure 12), and there is a high potential for more debris racking on the structure. However, under right flow conditions, more wood could mobilize and open up the side channel again. The logjam appears to be contributing to bank erosion at times, as water is deflected to the right around the debris, sometimes with significant head loss.

In the summer of 2018, the right bank of the creek along SR207 in this area was stabilized with a combination of rocks, logs with rootwads, and coir-wrapped soil (figure 13). This serves to stabilize the fill pad in this area, but is a temporary solution.

Figure 7. Area 2 in 2009. Note position of car.

Figure 8. Area 2 in 2010. Note position of car relative to bank.

Figure 9. Area 2 log jam looking upstream, in April of 2018. Note tree spanning channel upstream.

Figure 10. Area 2 in June of 2018. Note erosion behind rock revetment, and tree that was upstream in April now at logjam.

Figure 11. Area 2 looking west from highway April 2011.

Figure 12. Area 2 looking west from fill pad, June 2018.

Figure 13. Bank stabilization measures installed in summer of 2018.

Area 3

This area is immediately downstream of Area 2, roughly adjacent to MP 0.7 to 1.5 (see Figure 2). In this area, multiple channels form out of the side channel that starts in Area 2. The side channel changes from a single thread to a set of anastomosing channels, with significant amounts of wood and sediment deposits. As recently as 2004, a small pond is shown on USGS topographic maps, along with an adjacent campground. It is likely that the pond filled with sediment from the side channel that developed in 2007 (or earlier). The campground is gone as well.

The 1941 re-alignment project cut off the floodplain on the east half of the valley floor and excavated an entirely new, straight channel parallel to the new highway (see Figure 25, page 30). Riprap was added to the upstream bend in order to lead the creek into the straightened section, and a "ditch dike" was built on the upstream end of the straightened section to prevent flanking of the new creek alignment. It is unclear from the plans how this was built or what the dimensions were. Additional rip rap was installed sometime in the last 20 years along the same reach (Figure 13).

In 2007, Chelan County installed two culverts under SR207 to reconnect some flows to a historic channel on the east portion of the floodplain (Figure 14). The two culverts are both 12 feet in diameter. There appears to have been a substantial amount of sedimentation at the outlet of the upstream culvert since construction (Figure 15).

Figure 13. Rock revetment along SR207, April 2018.

Figure 14. Outlet twelve-foot diameter culvert, installed in 2007.

Figure 15. Sedimentation at outlet of upstream culvert to historic channel (photo from April 2018)**.**

3.0 Reach Assessment

3.1 Watershed Conditions and Land Cover

The watershed above the project reach is approximately 109 square miles in area. It is highly mountainous terrain. The watershed ranges in elevation from about 1930 feet above mean sea level (MSL) to about 8040 feet MSL. Most of the watershed is owned by the federal government and managed by the Wenatchee National Forest. About 21% is in wilderness. The canopy cover is approximately 70%, with the remainder being burned, clearcut, or alpine areas.

About 78 percent of the Nason Creek watershed is federally owned with the remaining 22 percent in private ownership, predominantly in the lower 15 miles of the floodplain and along the Kahler and Coulter Creek subwatersheds.

3.2 Geology and Soils

3.2.1 Geology

The Nason Creek watershed is underlain by the Nason Creek Terrane, which consists of metamorphic rock, predominantly Chiwaukum Schist (schist, amphibolite), along with granitic intrusion of the Mt. Stuart batholith (Figure 15). Overlying the Chiwaukum Schist is the Chuckanut Formation. Notably, much of the steepest portions of the watershed are underlain by the highly erodible granitoids and schists. The Bureau of Reclamation (2011) summarized the salient surficial geology features in the Lower Nason reach, which contains the project reach in its entirety. Figure 16 shows the surficial geology of the project reach. The floodplain has a major constriction towards its lower end, formed by a high Quaternary gravel terrace. Lower in elevation, more recent terrace confine, slightly, the current floodplain. Bedrock (Chumstick Formation) forms the left side of the floodplain, and in several places, the left bank of the active channel. This is interrupted by active alluvial fans draining Nason Ridge.

In the Nason Valley, Nimick (1977) mapped glacial deposits that are most likely correlative to those studied by Waitt (1977). Alpine glacial advances probably occurred in Nason Valley about 135 ky BP, 18 ky BP, 14.5 ky BP, and 11.5 ky BP (Waitt 1977), assuming these glacial cycles happened throughout the Northern Cascades. Advances of these alpine glaciers carved broad U-shaped valleys with oversteepened valley walls; their retreats constructed high terraces along the valley margins and filled the valleys with alluvium from broad outwash plains. Nason Creek and its tributaries have been reworking the deposits left behind along the valley floor as they laterally migrate and develop their floodplains.

The Bureau of Reclamation mapped the surficial geology of the Nason Creek corridor including the project reach (Figure 16). They showed that the Nason Creek valley is alternately constricted by older outwash gravel terraces related to alpine glaciers, and lower elevation, early Holocene (?) alluvial terraces. The project reach is located entirely in Holocene alluvial sediments, although the natural floodplain (without SR207) would be confined in varying degrees by glacial drift (mostly outwash).

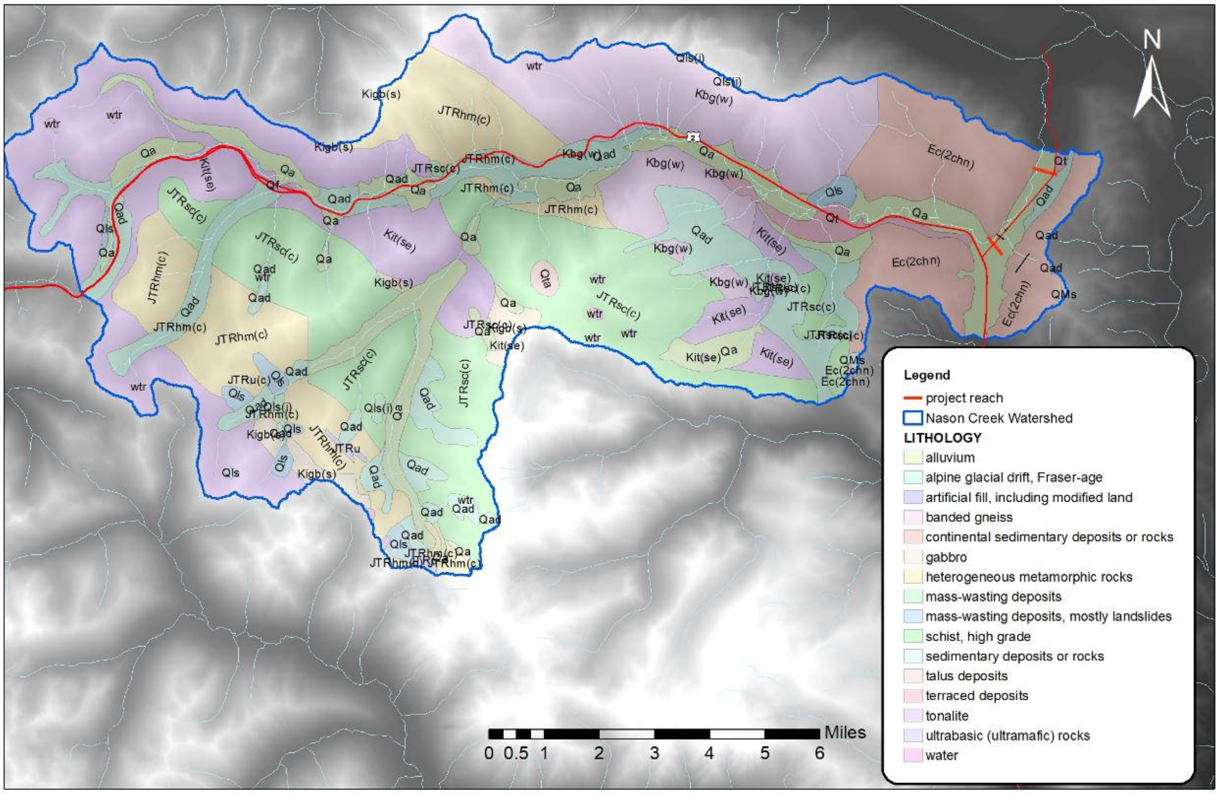

Figure 15. Geologic map of the Nason Creek Watershed (USGS 100K Geology GIS layer)**.**

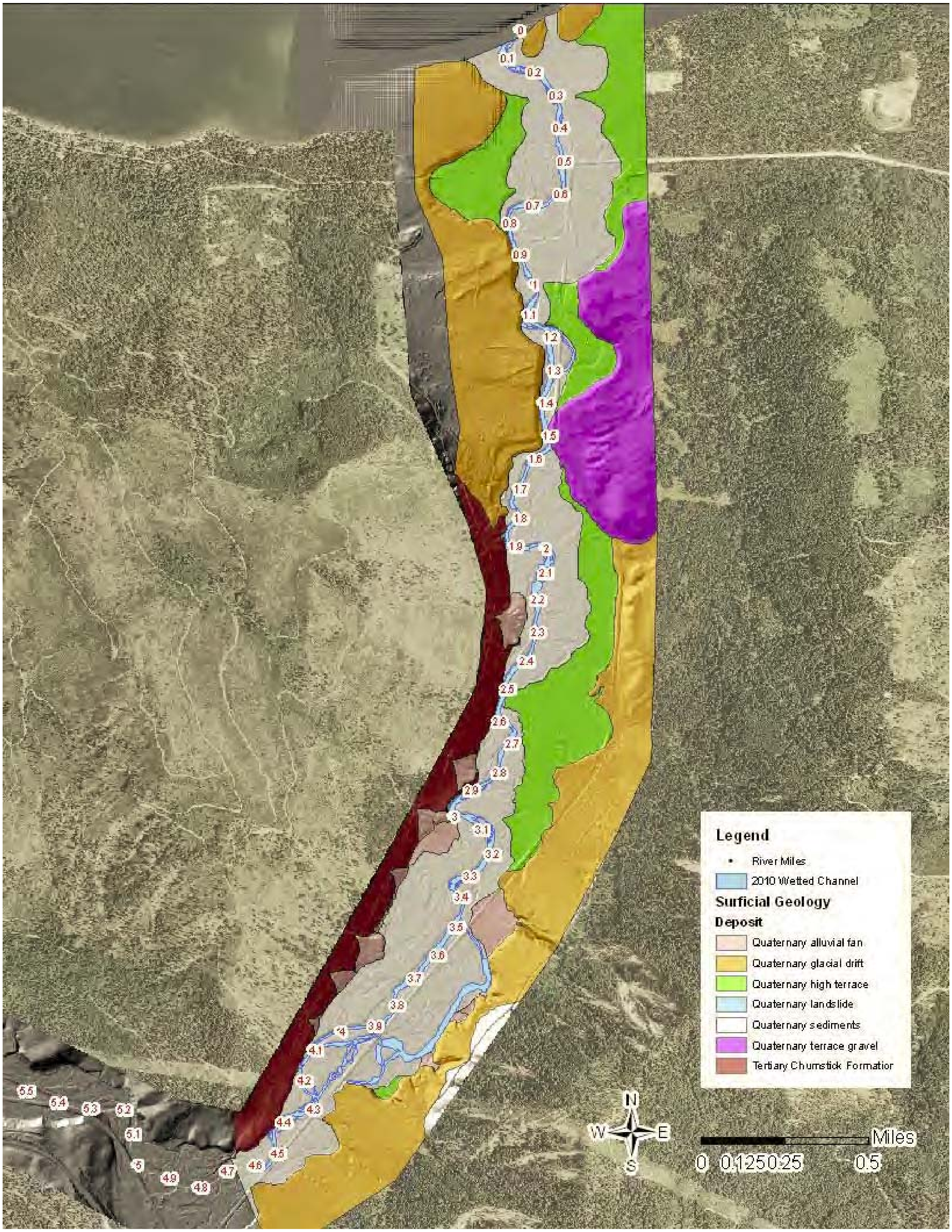

Figure 16. Surficial Geologic Map of lower Nason Creek (Bureau of Reclamation 2011).

3.2.2 Soils

The Nason Creek watershed is dominated by well-drained soils. The soils are geologically very young, being only developed since during the Holocene. Most of the soils are stony or boulder silt loams, or a combination of rock outcrop and stony soils. The steep slopes, along with the coarse-grained nature of the soils, means that in there is a ready source of sediment in the watershed.

3.3 Geomorphology

The project reach lies in a glacially carved valley, with steep sides and a relatively flat bottom. Nason Creek joins the Wenatchee River just downstream of Lake Wenatchee. The Bureau of Reclamation conducted an extensive study of the Nason Creek watershed in 2011. Much of the information in this section is derived from that report.

The project reach lies in a U-shaped trough with a valley bottom gradient of less than 3 percent. The stream channel is a predominantly unconstrained, moderately sinuous channel (Naiman et al. 1992). Channel bedforms consist of pools, riffles, and runs with a dominant substrate comprised of gravel and cobble with sand. Boulders are frequent in the more confined sections of the stream, generally associated with bedrock, areas of artificial bank protection (rip rap), and artificial channel confinement.

The Bureau of Reclamation delineated channel confinement for different portions of the lower Nason Creek channel (Bureau of Reclamation, 2011). Their results, shown in Figure 2 and modified for this document, are summarized below. The controls on confinement in the project reach are mainly bedrock, on the west, and alluvial terraces on the east. Based on LiDAR analysis, the various levels of terraces are a result of at least two high stands of Lake Wenatchee, and the subsequent incision of the glacial moraines associated with it.

The present project reach corresponds to river mile 3.5-4.5 (see Table 1). Average valley widths were measured using geologic controls to define valley bottom widths. Average channel widths were measured from the 2015 LiDAR hillshade elevation model based on bank/channel slope scarps.

Within the project reach (highlighted in green in Table 1), there is a moderately confined subreach upstream of an unconfined subreach. The boundary with the confined reach downstream of the project reach is marked by a high alluvial terrace that confines Nason Creek to the west side of the floodplain (though just barely). This confinement is important because it may decrease the slope of the channel upstream, leading to the development of multiple channel threads, which results in effects on the roadway prism.

The re-alignment of SR207 in the 1940s cut off almost half of the floodplain from channel processes. This has reduced the ability of the stream to store pulses of sediment from large storm events. We speculate that as a result, the remaining accessible floodplain is generally more subject to rapid channel changes.

Table 1. Project Reach sub-reaches and corresponding river miles and controls.

River Miles (BurRec, 2011)	Equivalent SR207 Mileposts	Valley Confinement	Average Valley Bottom Width (ft)	Average Channel Width (ft)	Geologic Controls
0.00-1.00	4.17-3.44	Unconfined	1520	100	Higher alluvial terraces, and glcial drift
1.00-1.52	3.44-3.07	Moderately Confined	380	115	Glacial drift and higher alluvial terraces
	3.07-2.92	Confined	204	114	Glacial drift and higher alluvial terraces
1.52-2.50	2.92-2.11	Unconfined	1080	95	Bedrock, terraces gravels, glacial drift, alluvial fans, and higher alluvial terraces
2.50-2.53	2.11-2.03	Confined	110	90	Bedrock and higher alluvial terraces
2.53-4.60	2.03-0.58	Unconfined	1090	115	Bedrock, glacial drift, alluvial fans, and higher alluvial terraces
	0.58-0.38	Moderately Confined	287	101	Bedrock, glacial drift
	0.38-.017	Unconfined	728	80	Bedrock, glacial drift
	Project Reach				

3.3.1 Channel geometry

The sinuosity of the project reach, calculated as the channel length divided by the overall valley length, is 1.21, which is relatively low. Based on the relict channels visible in LiDAR imagery, the sinuosity has been higher than it is currently. The average channel slope in the project reach is 0.42% (Bureau of Reclamation, 2011).

Channel cross-sections (Figure 17) were derived from LiDAR and are shown in Figures 18-23. They show that the width to depth ratio is moderate in the project reach. Seven cross-sections were placed in key locations throughout the project reach. Then, using ArcMap 3D Analyst, LiDAR elevation data were extracted at these cross-sections from the 2007 and 2015 data sets. The cross-sections were matched up by aligning the highway in each cross-section. The horizontal distance of the cross-sections were adjusted to make the roadway prism line up as closely as possible. Generally, the two datasets differed systematically in elevation by about 1.2 feet. Therefore, the elevation was adjusted. Notably, the thalweg of Nason Creek cannot be determined with this technique, since the water surfaces reflect LIDAR.

Figures 18 through 23 show elevation data for 2007 and 2015 at cross-sections 1 through 6. Cross-section 1 (Figure 18), shows the rip rap revetment that was reconstructed and expanded in 2011. The active channel appears to have been forced westward by several feet.

At cross-section 2 (Figure 19), about 10 feet of right bank erosion occurred between 2007 and 2015. In addition, a gravel bar about 4 feet high formed on the left side of the channel. At cross-section 3 (Figure 20), about 10 feet of right bank erosion is also seen. There is also some erosion of the far left of the floodplain, which is difficult to explain, but may be an error in post-processing of the data. Cross-section 4 (Figure 21), which is in the side channel area downstream of the log jam, shows a highly variable pattern of erosion and deposition. One of the two major channels in 2007 was completely filled in by 2015; there was also some erosion on natural floodplain to the left of the side channels.

Cross-section 5 (Figure 22), which is relatively short, is located in the area where the creek is against the highway. Similar to Cross-section 4, aggradation has occurred, though only about a maximum of 2.5 feet. Cross-section 6 (Figure 23) has shown very little change, with only about a foot of aggradation in the main channel.

Though not shown graphically, sedimentation at the outlet of the 2007 side channel culvert was evident in the comparison of LiDAR data. About 5 feet of sedimentation occurred over these 8 years.

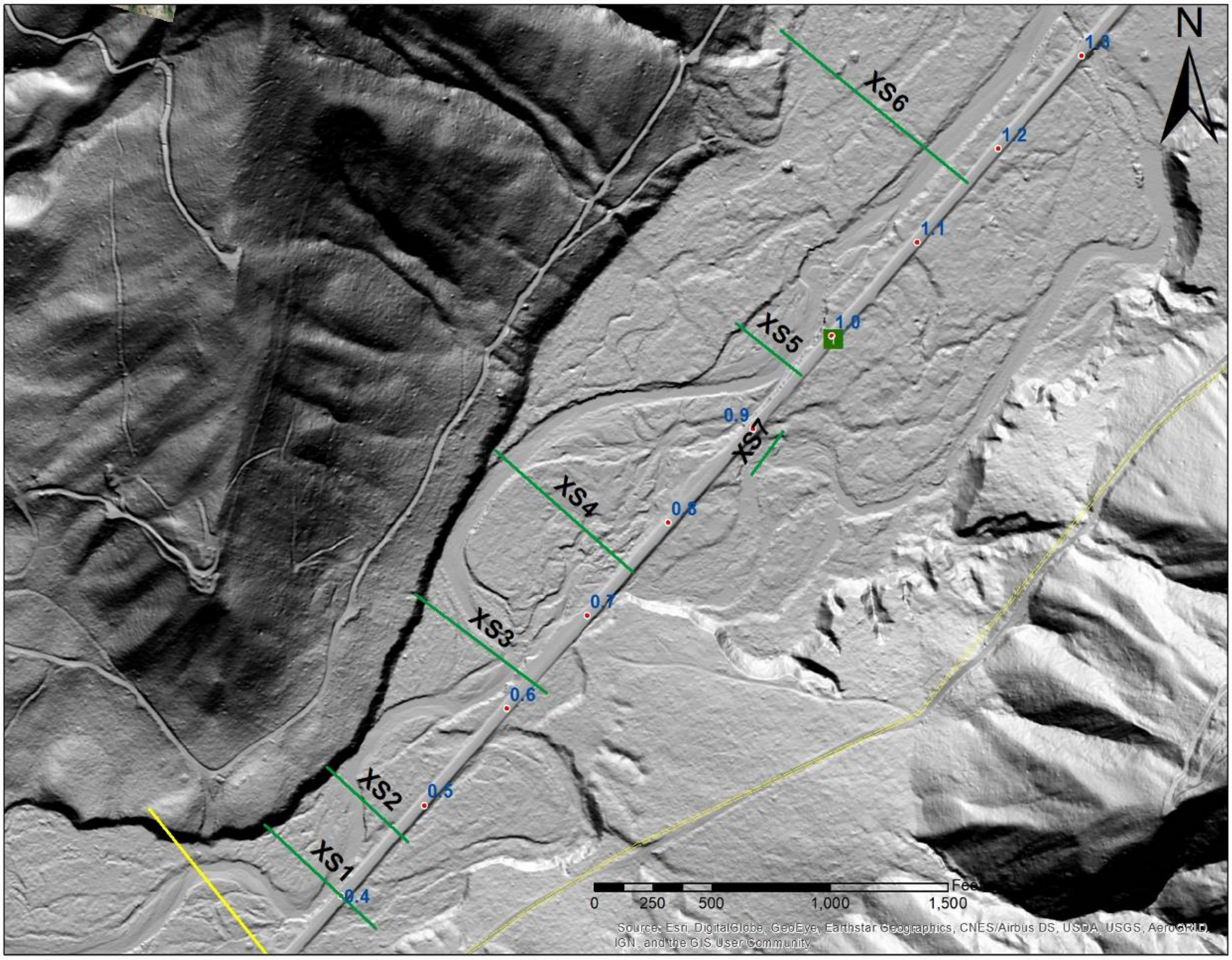

Figure 17. LiDAR map of project reach showing cross-sections. Data: 2015.

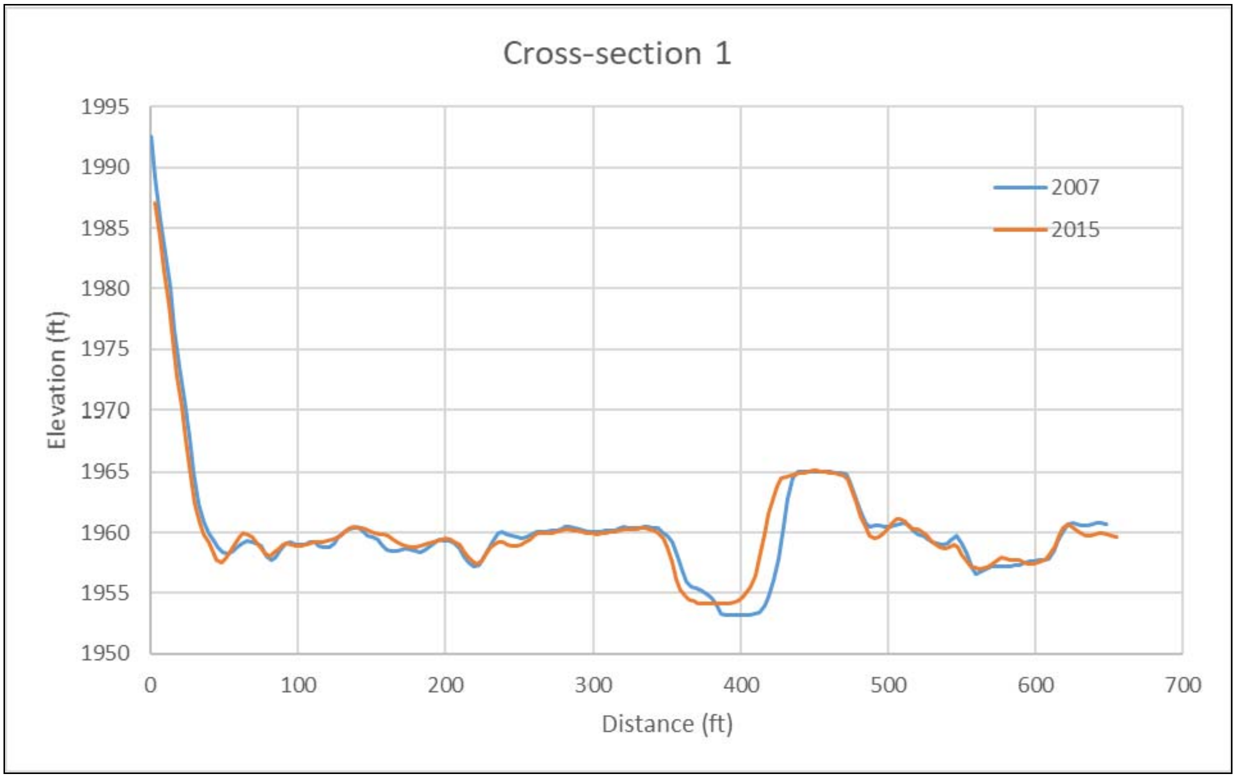

Figure 18. Cross-section 1 elevation data from 2007 and 2015 LiDAR.

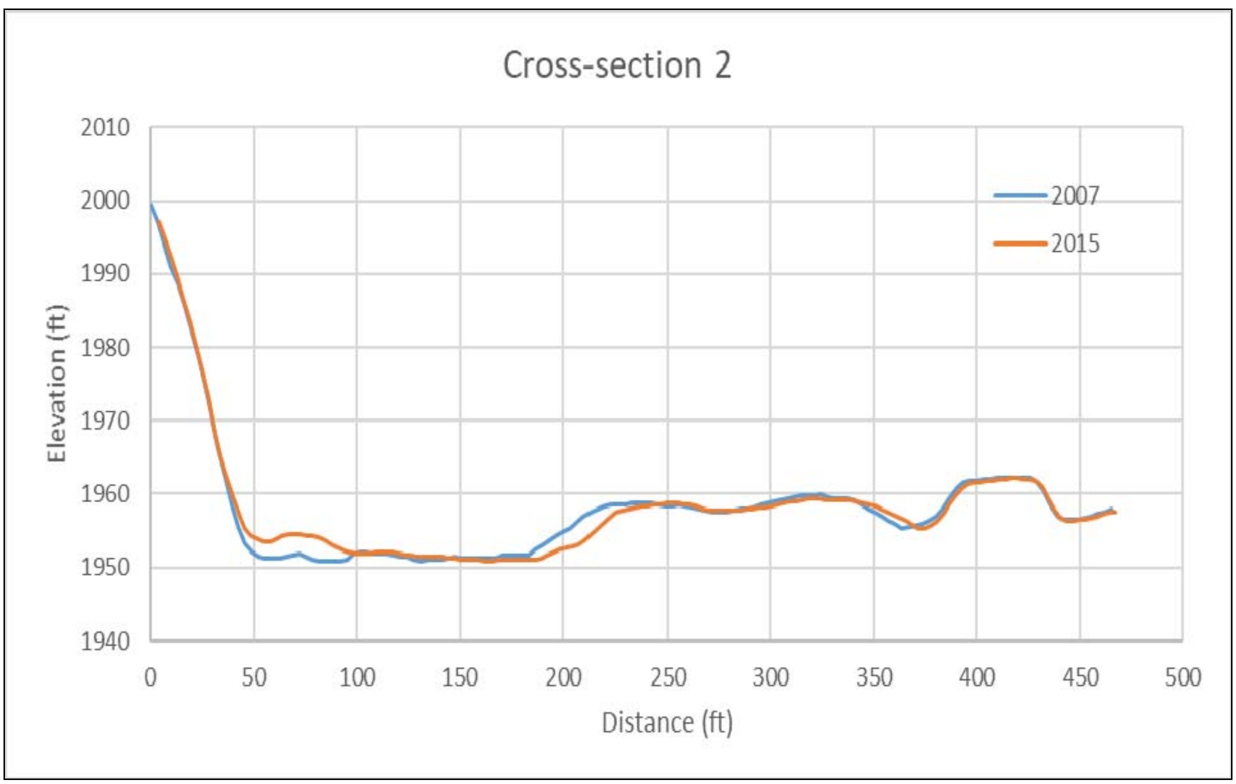

Figure 19. Cross-section 2 elevation data from 2007 and 2015 LiDAR

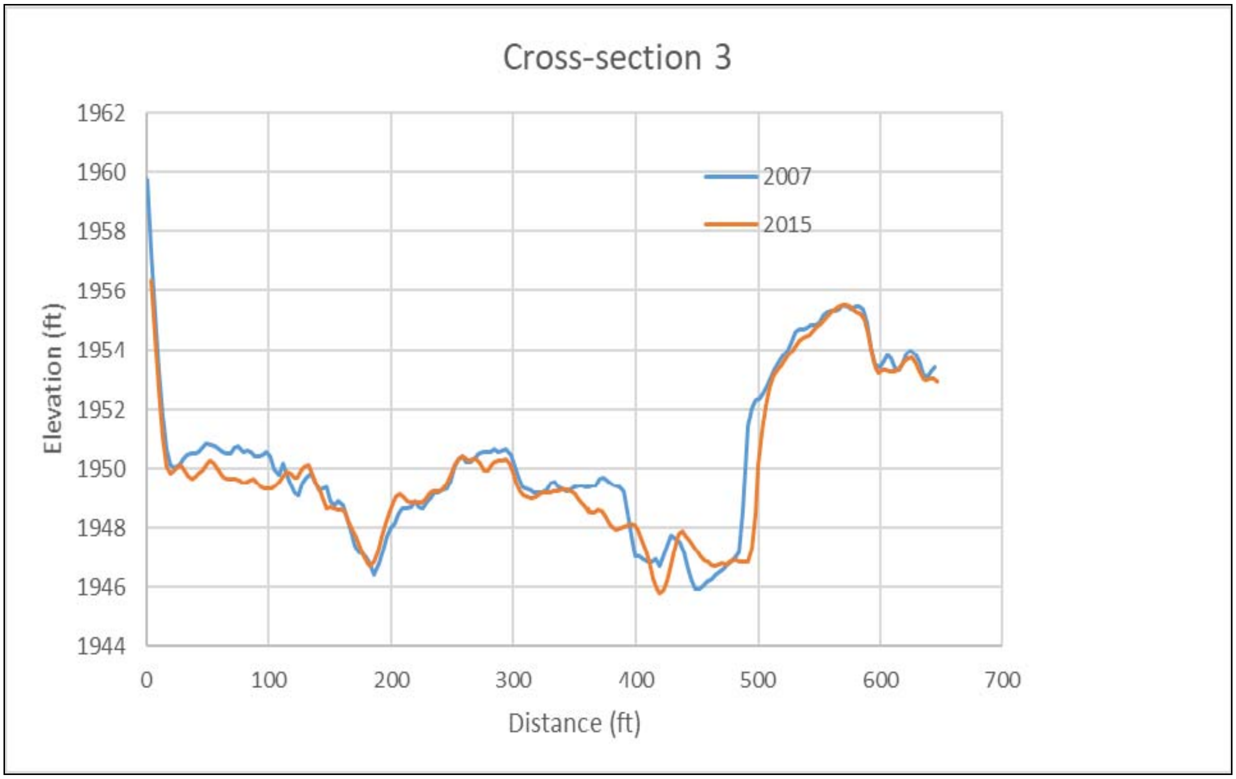

Figure 20. Cross-section 3 elevation data from 2007 and 2015 LiDAR

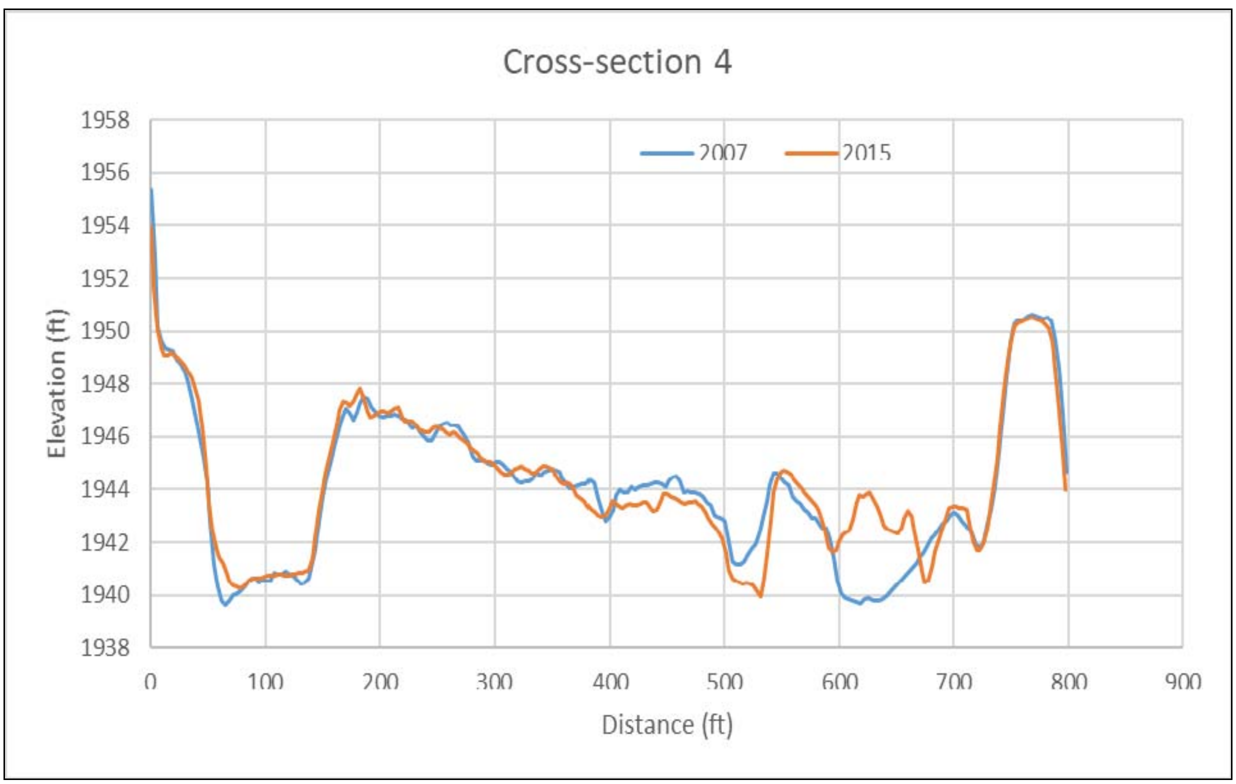

Figure 21. Cross-section 4 elevation data from 2007 and 2015 LiDAR

Figure 22. Cross-section 5 elevation data from 2007 and 2015 LiDAR

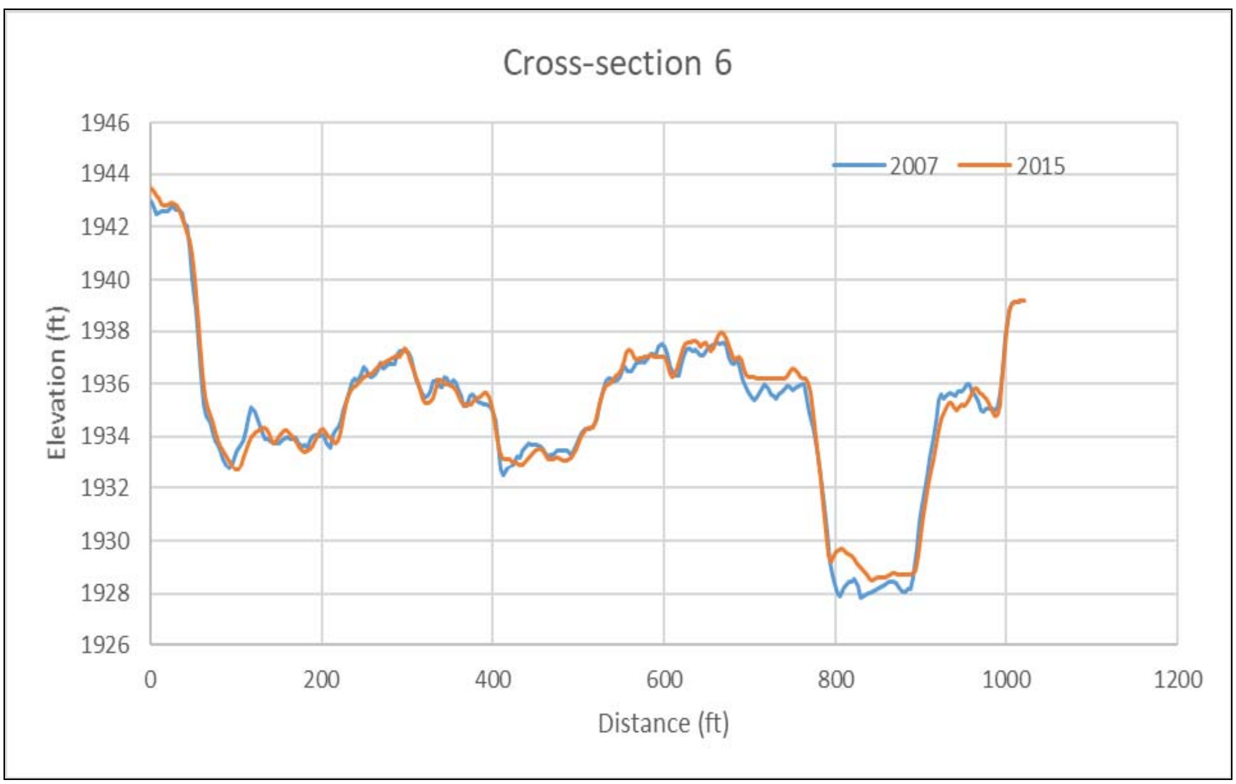

Figure 23. Cross-section 6 elevation data from 2007 and 2015 LiDAR.

3.3.2 Sediment load and size distribution

Nason Creek is predominantly a sand and gravel stream. Pebble counts collected in 2006 by the US Forest Service (unpublished data) at the upper end of the project reach had an average D50 of about 60 mm (2.4 inches).

Sediment sampling focused on fine sediment was conducted in 1993 and again in 2006 (US Forest Service, 2006). In 1993 the amount of fines in the streambed sediment was significant, averaging 22%. However, in 2006 it was much less at 12%. The study authors attribute this to natural variability.

3.3.3 Potential for aggradation, incision, and headcutting

While there are no glaciers within the watershed above the project reach, there is a great deal of sediment available from the steep slopes of Nason Ridge, Big Jim Mountain, and locally from tributaries draining Natapoc Ridge. The multi-thread nature of the channel in the project reach indicates that there is more sediment available than stream power to transport it (i.e., it is a transport-limited stream). The channel and adjacent floodplain are subject to pulses of sediment aggradation resulting from waning stream power due to variations in roughness, subtle changes in channel slope, and reduced stream power at the falling end of the flood hydrograph (or combinations of all three). The constriction downstream at the gravel terrace (shown in Figures 2 and 16) influences the slope of the reach, which contributes to aggradation of sediment.

3.3.4 Channel migration

The analysis by Bureau of Reclamation (2011) determined that Nason Creek in the project reach had a high potential for "overall lateral migration and floodplain re-working." Elevation patterns in the 2015 LiDAR are consistent with this.

An abbreviated channel migration analysis was performed by ICF International for Chelan County (Neal, 2011). They showed that meanders in the project reach have migrated down-valley by about 140 feet over 70 years, with accelerated movement in the last 30 years. For this study, we looked at the 2015 aerial photograph of areas 1 and 2, mapped the outline of the active channels, and cross-checked them with the 2015 LiDAR for comparison with the County's study. The results are shown in Figure 24.

3.3.5 Floodplains and connectivity

The natural floodplain in the project reach varies between 400 and 1700 feet wide. However, the SR207 road prism has cut off about 25% of the natural floodplain in much of the project reach. As mentioned above, the re-location of the highway to the floodplain in 1941 radically altered the stream-floodplain connection. Figure 25 shows the 1941 plans and where the channel was cut off. The hydrologic connection has been at least partially restored by the reconnection project sponsored by Chelan County, in 2008. The County, in cooperation with WSDOT installed two 12-foot diameter culverts under SR207 at MP 0.9 and 1.33 to reconnect a historic stream oxbow. This oxbow was formerly the mainstem of Nason Creek that was disconnected in the 1940s during the SR 207 realignment construction (Figure 25).

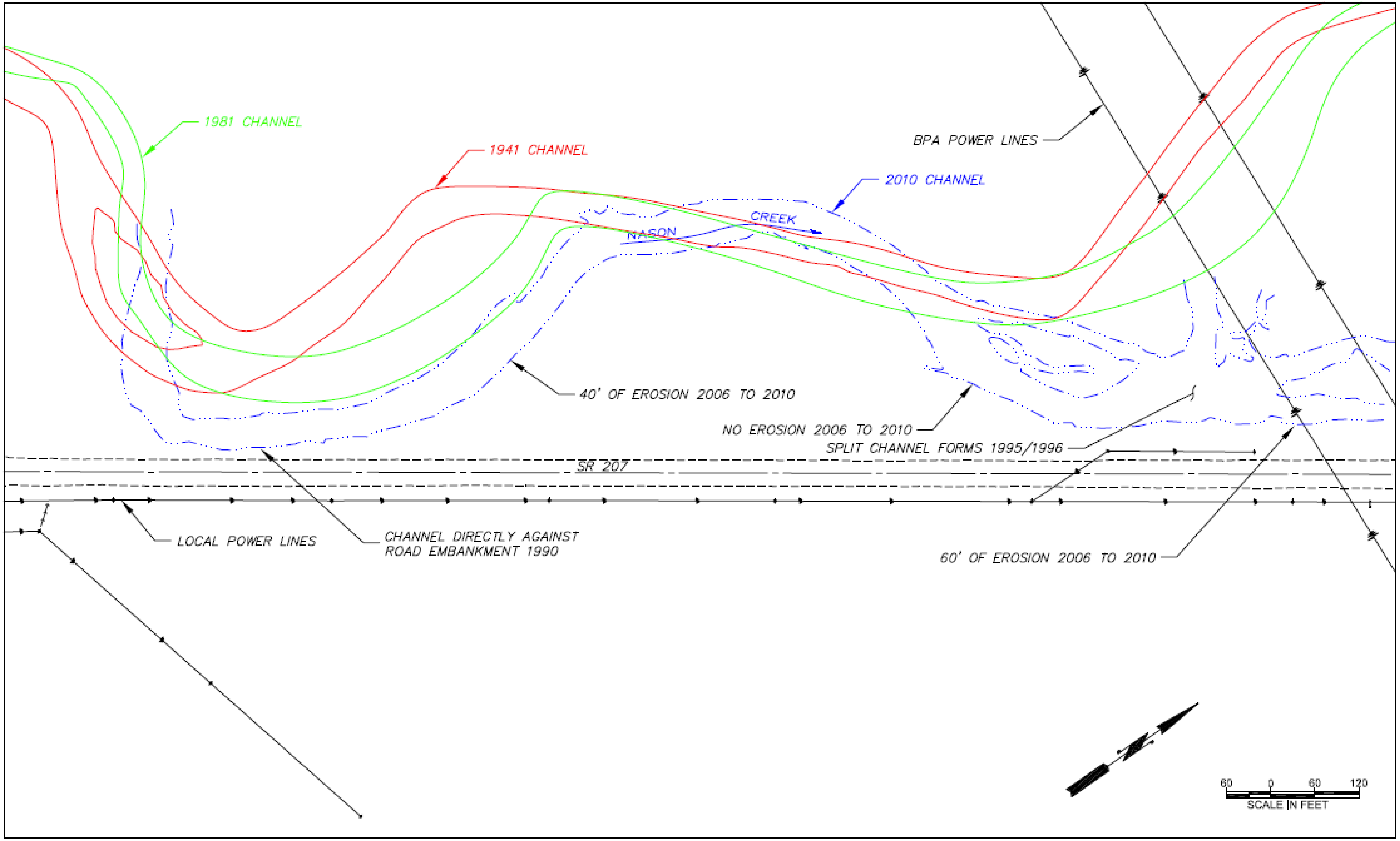

Figure 24. Channel migration, 1940-2010 (Bureau of Reclamation, 2011).

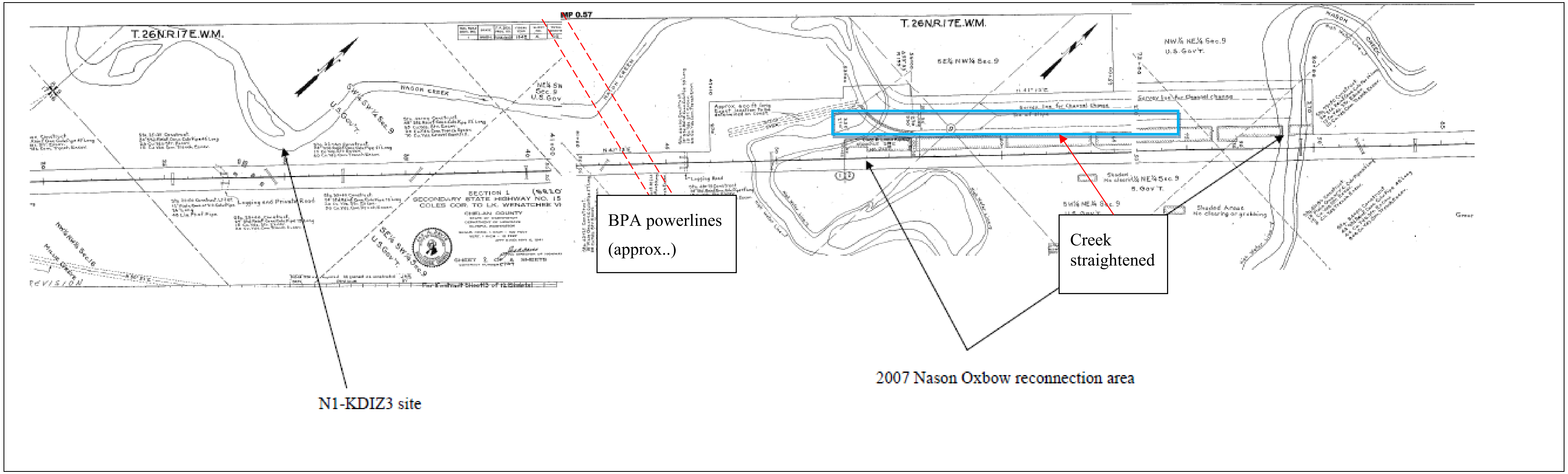

Figure 25. 1941 re-alignment plans in the project reach.

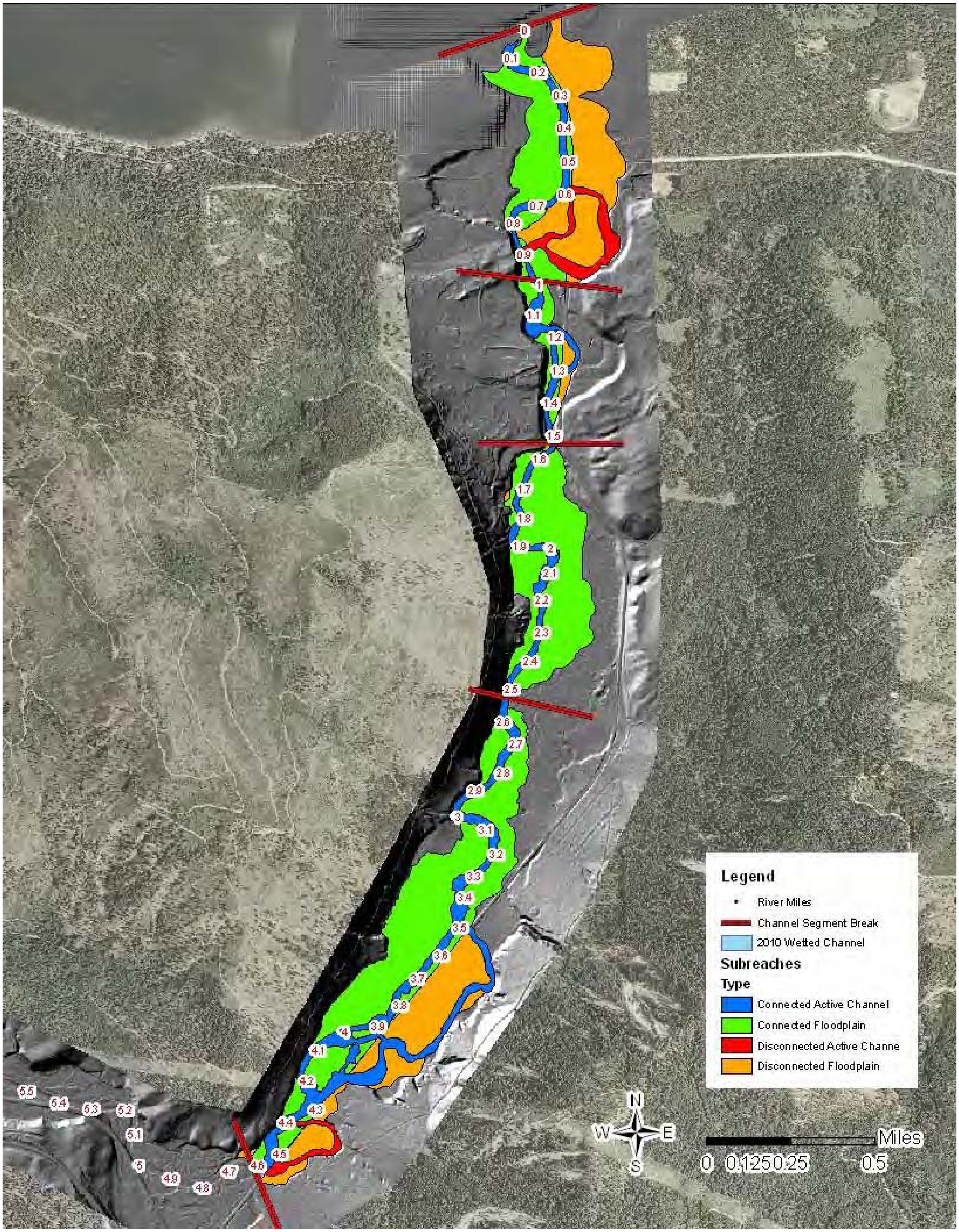

Figure 26. Mapped floodplain/channel connectivity (Bureau of Reclamation, 2011)

3.4 Groundwater

Groundwater through the project reach is estimated to be within 5 feet of the surface at all points of the floodplain, including parts of the floodplain that were isolated from the main flow of Nason Creek. This is due mainly to the high porosity of the alluvium that fills the valley floor, and the contribution of local runoff from Natapoc Ridge. Extensive wetlands can be observed in aerial photographs of the project reach.

3.5 Riparian Conditions and Large Wood

The project reach has an extensive riparian zone and a relatively abundant supply of large wood. Figure 27 shows the condition of riparian and floodplain vegetation as of 2006 (Bureau of Reclamation, 2011). Much of the riparian vegetation on the floodplain is large trees, either coniferous, deciduous, or mixed. The floodplain forests are extensive, as seen in Figure 27.

Large wood in the project reach is relatively abundant. As mentioned above, Area 2 has a substantial log jam that has been growing in size in recent years. In addition, Areas 1 and 3 have log jams (though smaller) at various locations throughout.

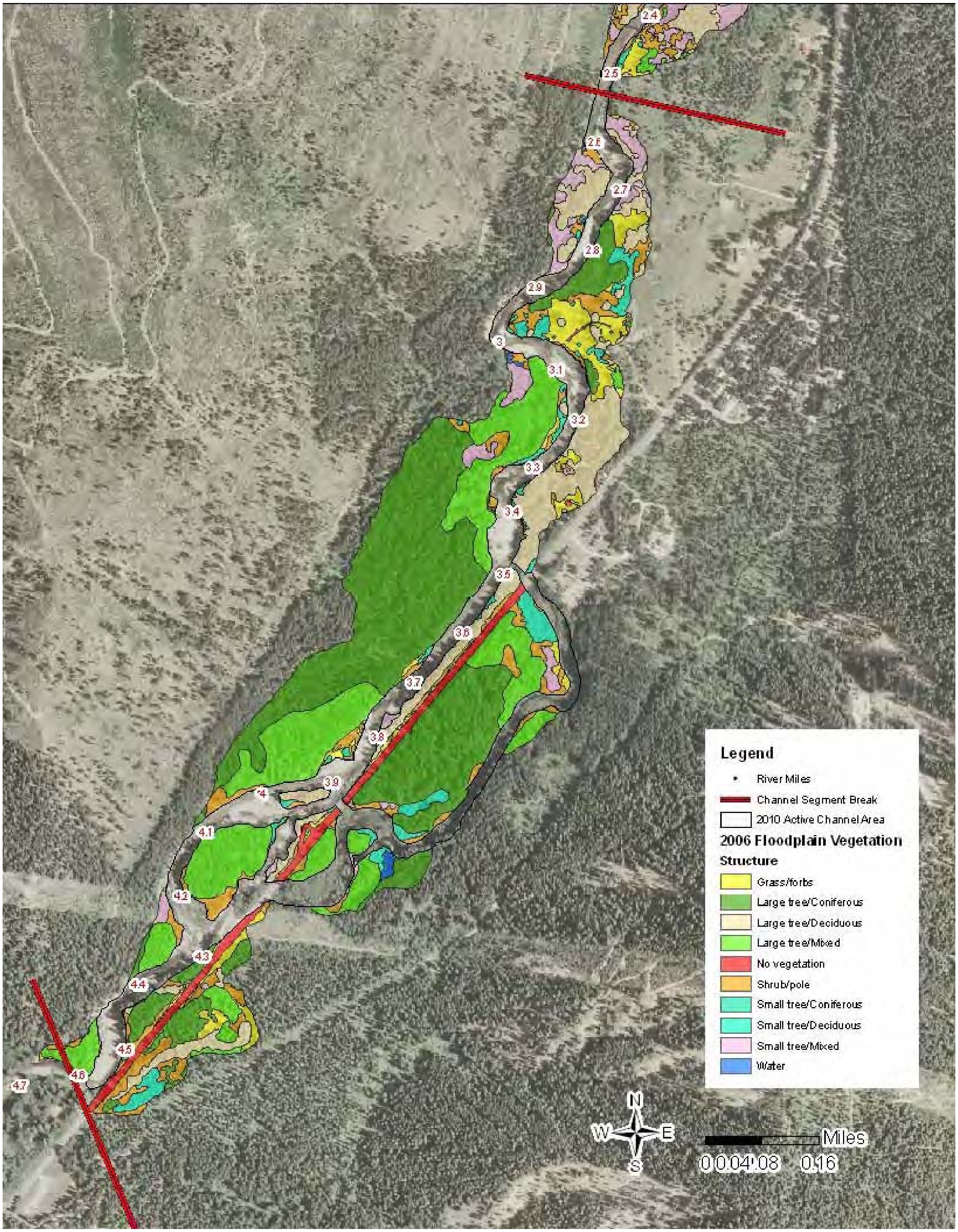

Figure 27. Map of riparian forest cover of the project reach (Bureau of Reclamation, 2011).

Figure 28. Typical deciduous riparian vegetation, Area 2.

Figure 29. Typical coniferous riparian vegetation, Area 3.

4.0 Hydrology and Peak Flow Estimates

The hydrology of the Nason Creek watershed is driven by precipitation in winter, followed by runoff during springtime melting of the snowpack. To estimate peak flood flow discharge estimates for Nason Creek at RM 1, we compared estimated peak flow discharges from three gages. The calculated results are shown in Table 2.

Table 2. Peak flood flow estimates for Nason Creek

*Bureau of Reclamation, 2008; **this study based on Nason Creek Ecology gage; ***this study using USGS gage data weighted with regional USGS regression equations

Recurrence Interval (yr)	Q (ft3/s)*	Q (Log Pearson III)**	Q (USGS)***
Q2	2700	3152	3190
Q5	4000	4171	3770
Q10	5100	4815	4130
Q25	6800	5603	4580
Q50	8200	6173	5000
Q100	9800	6728	5340

The Bureau of Reclamation (2008) conducted a peak flow analysis for the entire Wenatchee River Basin, including Nason Creek. Nason Creek peak flows were estimated at each river mile.

The Washington State Department of Ecology (Ecology) installed a stream gage on Nason Creek upstream of the confluence with the Wenatchee River in 2002. Since there is sufficient gage data, we used a log Pearson distribution analysis to determine the magnitude of floods of typical recurrence interval (Figure 30). Notably, these estimated discharges are much less than the Bureau of Reclamation estimates. Their study used the long record of flow on Icicle Creek. However, that watershed is much larger and has more high elevation terrain than Nason Creek.

For comparison, we also conducted an area/discharge ratio analysis of the Nason Creek watershed. This analysis used the USGS gage on Icicle Creek as a surrogate, and used the ratio of the drainage areas of the two watersheds and weighted the results with the USGS regression equation for region 2. The results are in the far right column of Table 2. These figures are lower than the result of the flood frequency analysis of the Nason Creek Ecology gage.

Of these three estimates, we suggest that the Nason Creek Ecology gage analysis most accurately estimates peak flows, since the gage is on the creek itself and has a recent flow record. Additionally, the Washington Department of Fish and Wildlife (2018) has predicted that Nason Creek is likely to experience significantly higher flows in future.

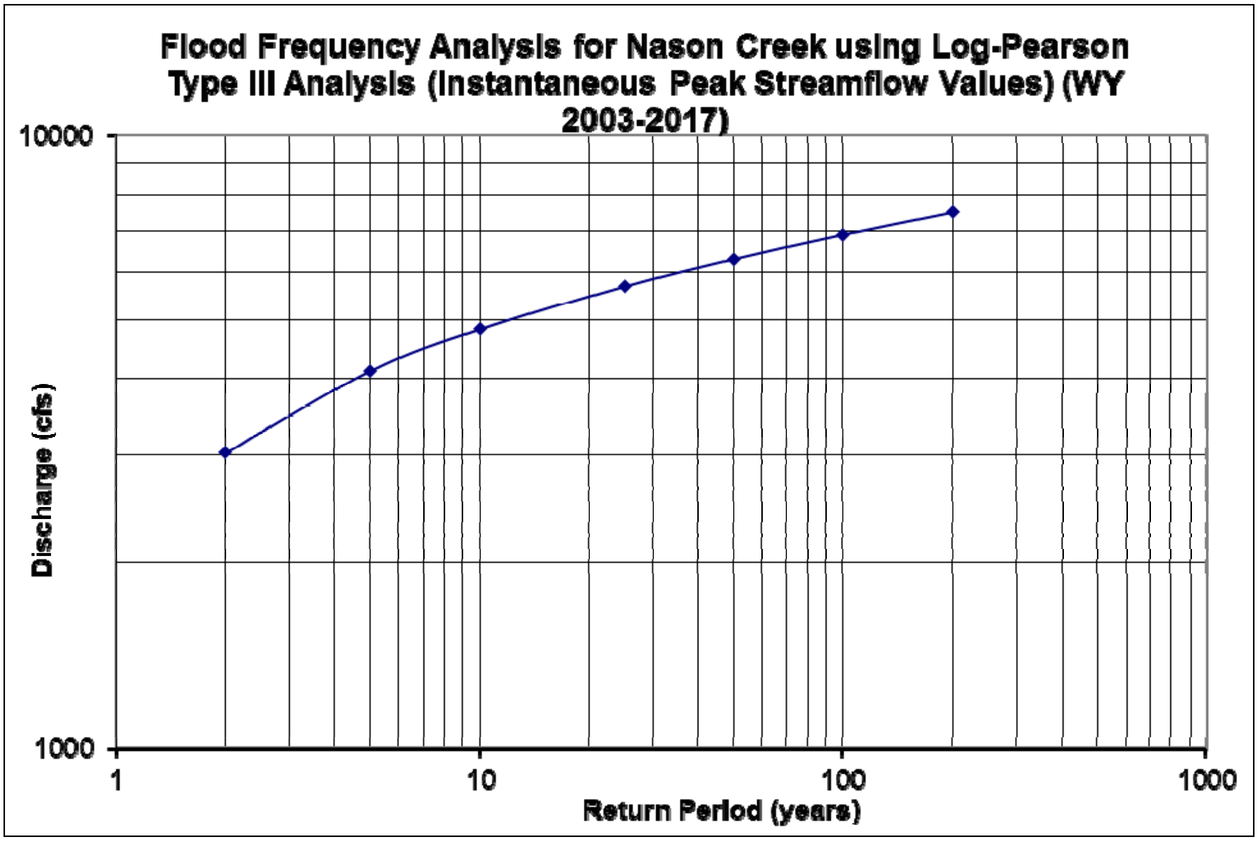

Figure 30. Log-Pearson Analysis of Nason Creek gage data.

5.0 Fish Habitat and Species

Nason Creek enters the Wenatchee River immediately downstream of the outlet of Lake Wenatchee, and has documented salmonid use by Upper Columbia ESU Spring Chinook salmon (*Oncorhynchus tshawytscha*), Upper Columbia River DPS Summer Steelhead (Oncorhynchus mykiss), Columbia River DPS Bull Trout (*Salvelinus confluentus*), Westslope Cutthroat Trout (*Oncorhynchus clarki Lewisi*), Rainbow Trout (*Oncorhynchus mykiss*), and Mountain Whitefish (Prosopium williamsoni) (SWIFD 2018). There is also a naturally reproducing population of Coho Salmon (*Oncorhynchus kisutch*) that is part of an ongoing reintroduction project since 2008 (Yakama Nation Fisheries, 2017). Currently, Spring Chinook salmon are listed as endangered, and Summer Steelhead and Bull Trout are listed as threatened under the Endangered Species Act. All three of these species currently have very low productivity throughout Nason Creek.

The study reach is currently used for spawning by anadromous Chinook, Coho, steelhead, and fluvial and resident bull trout. It is also used as a rearing and transportation corridor for all species that are present. All species of salmonids rely on adequate in-stream flows, low instream temperatures, complex streambank habitat, off-channel refuge areas, and instream cover for successful rearing. Bull trout, a species that is more sensitive to in-stream conditions due to its long residence and egg incubation time and lower temperature requirements, also requires adequate cover directly adjacent to spawning areas for successful spawning. Bull trout and Chinook salmon in particular, rely on consistent late-summer flows, low temperatures, and stable in-stream conditions for successful spawning in the late summer and early fall, and survival of redds throughout the winter months.

Current limiting factors for salmonids in this basin include low instream flows, high water temperatures, channel instability, sedimentation, and limited instream habitat diversity (UCSRB 2007). Nason Creek has had its floodplain cut off by SR 207, US 2, and a railroad grade throughout much of its path, which has reduced water storage capacity in off-channel areas, riparian vegetation quality, and caused channel instability during high flows. This resulted in streambank erosion, sedimentation, loss of instream and overbank cover, and loss of habitat complexity. Throughout the study reach, the east bank of the stream adjacent to SR 207 has rip rap along the channel margin, limiting channel complexity, instream cover and vegetation. According to the Recovery Plan (USCRB 2007), the highest priorities for protecting and increasing biological productivity is to allow unrestricted stream channel migration, complexity, and floodplain function, and restore the complexity of the stream channel and floodplain with an emphasis on promoting habitat diversity, instream flows, and water quality throughout the watershed.

6.0 Evaluation of Treatment Alternatives

6.1 Causal Mechanisms

The Nason Creek floodplain has been bisected by SR207. Additionally, Nason Creek has an active stream channel with a transport-limited system. As a result, the highway adjacent to it is experiencing erosion at various locations. The relatively low amplitude meanders are migrating in a down valley direction as sediment deposits on point bars and high shear stress on active meander bends work in concert. This has inevitably engaged with the road prism. It is currently flowing against the road prism in three sections, and could over time engage with longer or additional sections.

The persistence of the log jam at MP0.65 has likely shunted the bulk of the flow to the west away from the highway, but some of the flow that does make it past has been eroding the soft shoulder of the highway. Additional erosion is likely, as is the failure of the log jam at some time in the future. This could severely erode several hundred feet of highway and entrain the main flow of the channel along it. Furthermore, the highway is subject to overtopping by floodwaters at this location (Chelan County 2011).

6.2 Abating the Primary Mechanisms of Failure

A study produced previously by Chelan County recommended highway relocation, roughly to where it had once been near the toe of the eastern valley sidewall. However, due to avalanche concerns and lack of funds, that option was dropped from consideration (Bill Gould, personal communication to Jenifer Goodridge, Chelan County, 2009).

Each area has somewhat different causal mechanisms. Area 1 is in a constricted floodplain at the outside of a sharp meander bend. The upstream bend in the river, along with the sediment load and the backwater effect, result in sediment that is prone to dropping out on the point bar on the inside of the bend opposite the highway. This forces flow against the highway by displacing area in the channel cross-section.

Working with the existing alignment, re-directing the flow momentum would keep the thalweg from eroding the toe of the road prism. The existing barbs have been protecting the slope by redirecting flows. However, they are coming apart and will reach a point of ineffectiveness. Additionally, the barbs and rip rap revetment have precluded establishment of any riparian vegetation, and thus represent a permanent loss of habitat and habitat function. To address the potential for future erosion the loss of habitat, large wood should be incorporated into structures that will continue to re-direct flow away from the roadway embankment.

In Area 2, erosion of the right bank is an ongoing threat created in part by the highway location in the middle of the floodplain, but it is exacerbated by the growing log jam at the outside of the meander bend that is working its way down-valley. A point bar on the inside of the meander bend is expanding and forcing flow on the opposite bank where the highway is located. Addressing the causes involve stabilizing the existing bank and stabilizing the log jam so that it does not break up, which may allow more of the mainstem to flow into the side channel along the highway. Additionally, the roadway surface is low enough to be occasionally affected by flooding. Flood frequency could be reduced by expanding other channels in the floodplain cross-section.

In Area 3 the highway has not been greatly affected by erosion, though there have been some additions to the 1940s revetment. However, the ongoing loss of riparian processes and floodplain connectivity remains a concern. This could be addressed by adding floodplain roughness and opening up former side channels in the adjacent floodplain opposite the highway to improve connectivity, increase floodplain complexity, and allow for improved riparian interaction.

7.0 Treatment Alternatives

7.1 Introduction and objectives

The primary objectives in any project to abate these problems are to:

- Minimize highway closures due to flooding.
- Minimize future maintenance costs.
- Ensure the safety and integrity of the highway.
- Maximize natural movement of sediment, large wood, and water through the reach.
- Minimize impacts to fish and wildlife species resulting from continued maintenance and emergency actions, particularly those that are listed as endangered, threatened, or sensitive.
- Account for future changes in streamflow due to climate change

7.2 Alternatives Considered

We considered three different alternatives for addressing the Chronic Environmental Deficiency on SR 207. This includes a No Action alternative, relocating the highway to its previous alignment on the edge of the floodplain, and implementing a suite of treatment methods in three different treatment areas along the highway in its current alignment. Table 3 shows a comparison of alternatives by area within the project reach.

7.2.1 No Action

Under this alternative, no specific measures would be taken to address the threats to the roadway at each site. Further response would be emergency actions only. Mitigation could be required for the resulting instream work. The barbs in Area 1 are deforming and will eventually lose their effectiveness at re-directing stream flow. Additional rock would likely be added during emergencies to protect the highway.

Area 2 could see continued erosion of the fill pad and possible erosion of the road prism. While the log jam has recently racking additional wood, flows could be redirected around the jam and into the fill pad. Additionally, degradation of wood in the logjam over time could lead to a gradual or catastrophic failure of the jam, leading to an unknown and difficult-to-predict amount of erosion.

Instability in Area 2 could eventually affect Area 3, possibly by plugging the floodplain connection culvert installed in 2011, or leading to erosion of the riprap along the highway embankment at MP0.9-1.0. The meander of Nason Creek is migrating down-valley and is likely to have an effect on channel morphology.

7.2.2 Highway Relocation

Notably, although highway relocation would be the alternative that benefits habitat the most and minimizes maintenance, it was not considered here since it was ruled out in previous discussions (Bill Gould, WSDOT, personal communication, 2018) based on a risk of snow avalanches affecting the re-aligned highway. Additionally, Chelan County has since constructed culverts under SR207 that provide some connectivity to the former floodplain southeast of the highway.

7.2.3 Channel Treatments within the Existing Highway Configuration

Under this alternative, the highway would remain in its current alignment and in-water work would focus on improving habitat and protecting the highway prism. We recommend a set of measures that enhance some habitat processes while reducing effects of flows on the highway embankment. The types of treatments are described below, followed by a description of the treatment areas and how the treatments are configured within each area. The recommended treatments for each area are shown in Figures 31 through 33. The concepts and locations presented here are conceptual and would need to be refined based on hydraulic studies of water surface elevations, scour, and velocities.

Bank-based engineered log jams (ELJs) – Areas 1 and 2, and 3. We envision a 4-log configuration that would be partly ballasted by burial into the bank of Nason Creek. The racked logs would be held in place by wood pilings driven into the stream bed. This concept assumes that piles can be driven to sufficient depth to be stable. While ELJ design could differ from this conceptual design, we feel that four logs are the minimum needed to be effective at deflecting flow, creating quiescent, adjacent areas downstream, and racking additional wood.

Mid-channel ELJs – Areas 2 and 3. These structures would be placed in the floodplain adjacent to the active channel or where the channel may migrate to. The structure should be stable from multiple directions. Therefore, it would be roughly square in plan view, and consist of two layers of logs perpendicular to each other. The logs would be held in place by wood piles, 12-16 inches in diameter. The logs would be 25 feet long, including rootwad, and 24 inches DBH. The interstices of the structure would be backfilled with streambed sediment and top soils, and planted with appropriate riparian species. These structures would add complexity to the channel, increase floodplain roughness, and eventually naturally recruit wood and vegetation.

Rock revetment with log toe – Area 2 on the right bank below the log jam. The large rock protects the bank, and wood is added to the structure to deflect flows and to reduce effects on habitat. The revetment would consist of appropriately sized riprap overlying 24-inch DBH logs, 20 feet in length. The rootwads would be spaced 10 feet on center, allowing for sediment accumulation in the quiescent water in the gaps. The centroid of each rootwad would be placed at the elevation of the thalweg to maximize the interaction with the stream and improve habitat function. The protrusion of the rootwads into the channel should be variable (plus or minus 5 feet), to add more complexity and racking potential.

Side channel excavation – Area 3. In order to increase off-channel habitat and reduce flood elevations, we recommend shallow excavation to reactivate former side channels. Two alternative alignments are presented for Area 3. The side channel would be about 15 feet wide with a defined thalweg, and connected at low flow to the main channel on the downstream end.

On the upstream end, the elevation of the side channel thalweg would coincide with the elevation of the 1.5-year flood. This feature is not intended to capture all of the regular flow, but only be activated at higher stream flows. Hydraulic modeling would be needed to design either side channel.

The longer side channel option is approximately 3300 feet long, while the shorter option is 1300 feet long. Factors in deciding which of these should be constructed include amount of disturbance, loss of canopy, and cost.

Gravel bar excavation – This is proposed only in Area 2. The area excavated would be about 300 feet long, and 70 feet wide at the upstream end, tapering to 30 feet wide at the downstream end. Because of the relatively small elevation difference between the pavement and the channel at this location, gravel bar excavation is recommended to increase the capacity of the stream channel and divert flows away from the highway, and reduce flooding of the roadway during high-flow events. As mention in section 3, the existing gravel bar has accumulated and grown in recent years due to the logjam under the BPA power lines. Excavation will take some of the sheer stress of floods off the right bank of Nason Creek.

Add wood to existing barbs – Area 1. Adding wood to the rock barbs in Area 1 could provide some habitat benefits and increase flow deflection. We feel that this can be done with partial reconstruction of the barbs. In one case, existing LWM that has racked naturally could be pinned in place by either wood piles (proposed) or rock anchors. Another barb could be supplemented by three logs with rootwads, anchored by the addition of rock ballast. The rock size would be determined by large wood stability analysis.

7.3 Comparison of Treatment Alternatives

Table 3. Alternative summary matrix.

Location	Alternative	Description	Advantages	Risks	Habitat Effects	Relative Costs
Project Reach	Road relocation	Construct new highway alignment on the base of Napotoc Hill, out of the floodplain; abandon and remove existing roadway	Fully restores floodplain connectivity and habitat; eliminates maintenance related to channel migration	Could be subject to snow avalanches during heavy snow years	Improves habitat in side channel and mainstem; allows for full recovery of riparian areas	Very High
Area 1	No Action	No change in bank configuration	No additional permitting	Continued maintenance activity; more	Addition of more rock revetment likely.	Low (short term); Moderate (long term)

	Bank-based enhancement and stabilization	Rebuild stream barbs to incorporate large wood; add new bank-based ELJs using wood piles	Reduce risk of outflanking of existing structure; prevent translation of erosion downstream	Could raise flood water elevation	Adds large wood to this part of the project reach; adds habitat complexity	Moderate
Area 2	No action	Respond to bank erosion as needed	No additional permitting	Risk of major flood eroding roadway prism; entrainment of side channel against right of way	Reduces complexity through emergency addition of rip rap as needed.	Low (short term); High (long term)
	Bank-based treatments and side channel expansion	Install series of bank based ELJs using wood piles if possible; log and rock toe; excavate into point bar to expand old side channel; strategic placement of ELJs to force higher flows into side channel.	Reduce the risk of highway erosion; minimize emergency actions	Permitting and construction possibly complex	Increases habitat complexity; adds LWM to the system	Moderate to high
Area 3	No action	Channel and highway remain in current configuration	No additional permitting	Emergency action needed periodically as rip rap is eroded; side channel culvert subject to plugging	Lack of floodplain connectivity; legacy effects of channel straightening remain	Low to Moderate
	Streambank and floodplain treatments	Construct side channel, install mid-channel ELJs in floodplain; install bank-based ELJs to deflect flows	Reduces velocities and shear stress; reduces rip rap maintenance over time	Side channel may get plugged with debris	Greatly increases floodplain complexity and connectivity	High

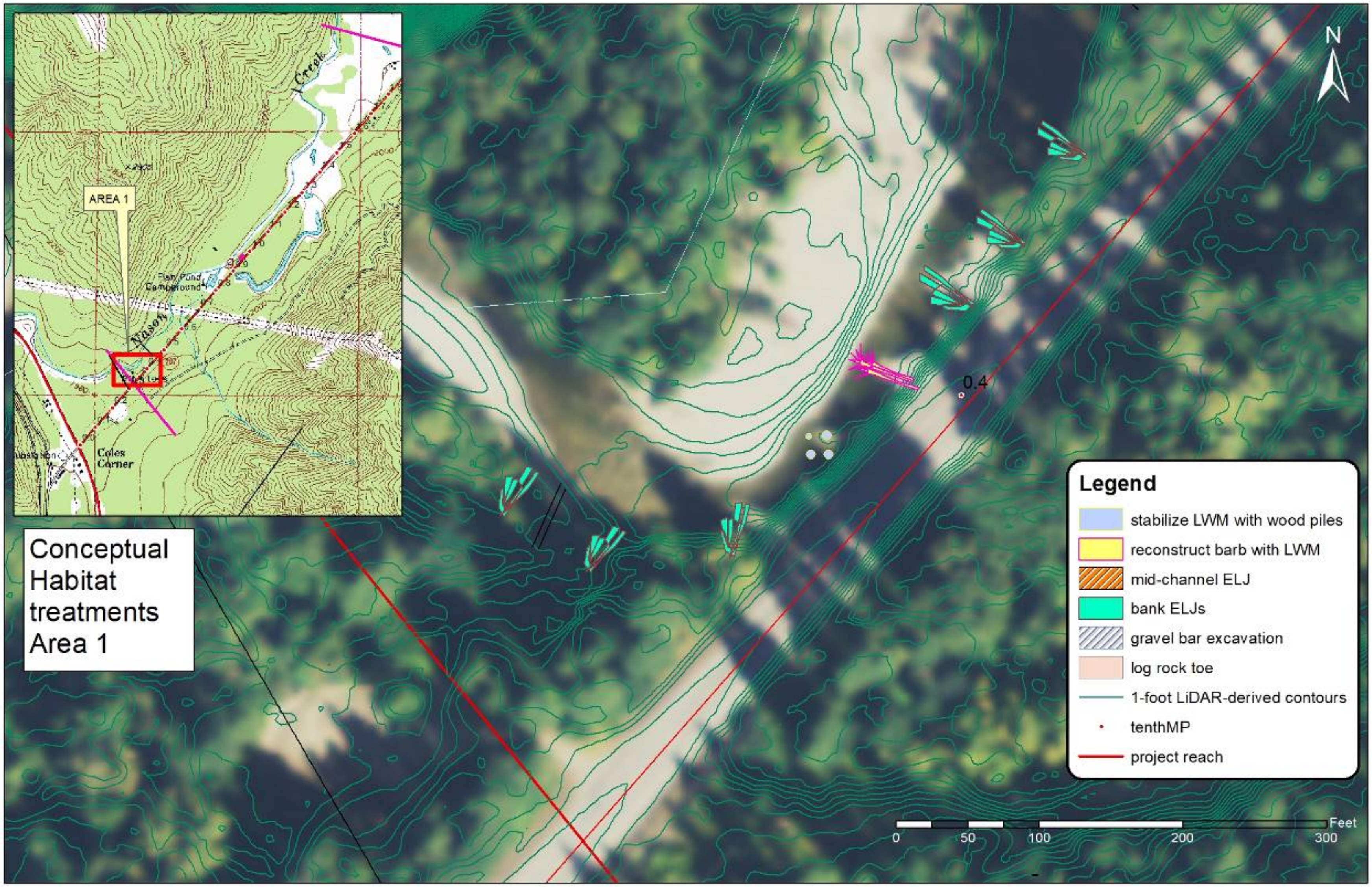

Figure 31. Conceptual treatments for Area 1.

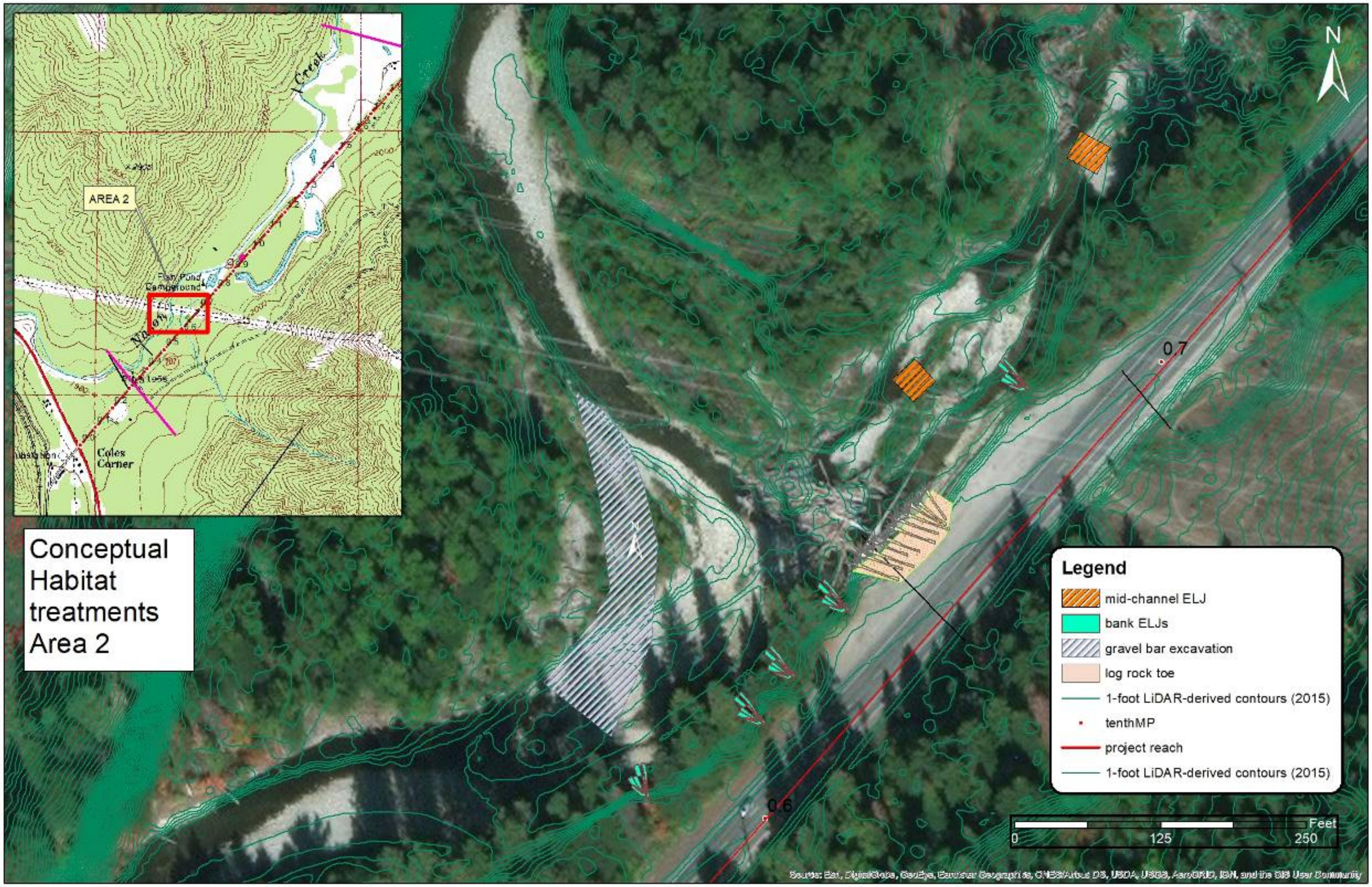

Figure 32. Conceptual treatments for Area 2.

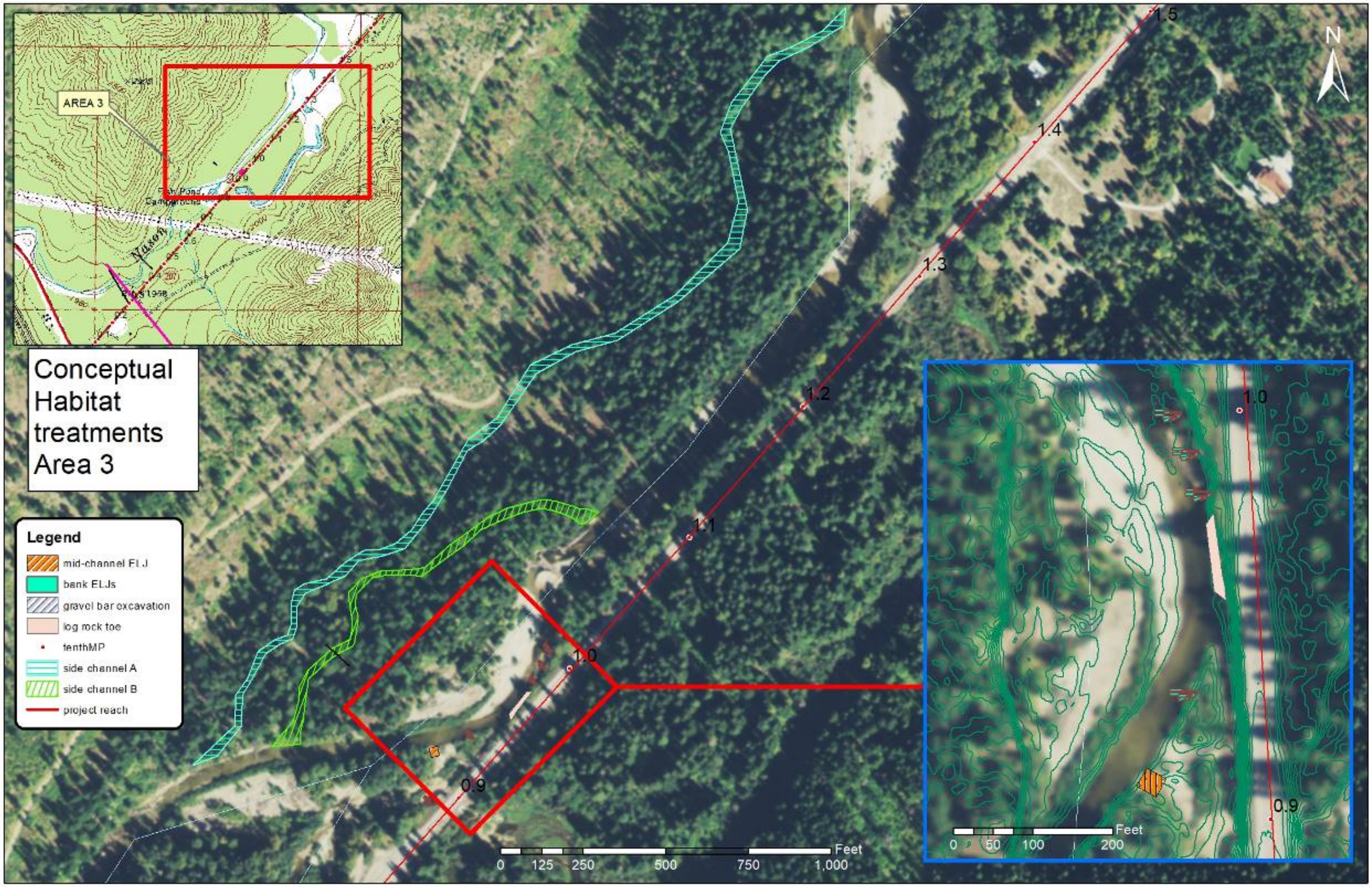

Figure 33. Conceptual treatments for Area 3

7.4 Recommended Treatment Option – Stream-based treatments, Areas 1, 2, and 3

This alternative would protect the highway while minimizing effects to aquatic habitat in some areas, and enhancing habitat in other areas. Drawings shown in Figure 31, 32, and 33 show the conceptual layout of the various recommended treatments. These would likely need to be constructed over more than one year.

The Yakama Nation, which is very interested in habitat restoration in the area, is currently conducting a geomorphic analysis and alternative assessment in the same project reach. Initial outreach to the Tribe indicates that a partnership is possible. WSDOT will be working with the Tribe to reach an agreement on a set of projects to carry forward to design. This will be done in consultation (concurrence) with WDFW.

8.0 Conclusions

Nason Creek is an active mountain stream with an abundant sediment supply. Following re-alignment of the state highway that bisected the floodplain, the creek has been eroding SR 207 in several locations. Maintenance to protect the roadway prism is ongoing, and the highway remains threatened in the area underneath the BPA power lines (Area 2).

Aside from re-connecting the creek with its historic floodplain by removing the roadway, the best option for protecting the roadway, minimizing maintenance, and minimizing effects on aquatic habitat, is to use various in-channel treatments to redirect stream power away from the highway. We recommend a series of stream-based treatments to protect the highway and to improve aquatic habitat and processes. These include rebuilding the rock barbs in Area 1 to include substantial amounts of large wood; stabilizing the log jam at Area 2, installing bank-based ELJ flow deflectors in Area 2 along the right bank upstream of the eroding area; excavating a gravel bar at Area 2 in order to widen an existing side channel; installing mid-channel ELJs in Area 3; and re-establishing side channels in the floodplain of Area 3.

Each of the recommended actions would require hydraulic modeling to further the design. The configuration of the each of the potential treatments would be refined based on the results of the modeling.

9.0 Interim Maintenance Plan

Until funding, design and construction of the selected alternatives is complete, maintenance may be necessary, particularly at Area 2. A stockpile of logs with rootwads and rock could be staged at the pullout. These could be used in the event that the bank immediately upstream of the 2018 repair erodes further toward the highway. The potential fix would look similar to the 2018 maintenance, possibly with a closer spacing of logs.

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