Draft Alternatives Evaluation Report

Nason Creek Lower White Pine Habitat Reconnection Project

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Contents

Tables

Page

Figures

Follows Page

Acronyms and Abbreviations

1D	one-dimensional
2D	two-dimensional
BNSF	Burlington Northern Santa Fe
BPA	Bonneville Power Association
CBG	concrete box girder
CCNRD	Chelan County Natural Resource Department
cfs	cubic feet per second
DPG	deck plate girder
DPS	Distinct Population Segment
Ecology	Washington State Department of Ecology
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FEMA	Federal Emergency Management Agency
GIS	geographical information system
LiDAR	light detecting and ranging
LWD	large woody debris
MP	milepost
mm	millimeters
PAB/UB	palustrine aquatic bed/unconsolidated bottom
PEM	palustrine emergent
PFO	palustrine forested
PSS	palustrine scrub-shrub
Reach Assessment	Lower White Pine Reach Assessment
Reclamation	U.S. Bureau of Reclamation
RM	river mile
SR	State Route
TPG	through plate girder
Tributary Assessment	Nason Creek Tributary Assessment
UCR	Upper Columbia River
UCRTT	Upper Columbia River Technical Team
UCSRB	Upper Columbia River Salmon Recovery Board
US 2	U.S. Highway 2
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation

Chapter 1
Introduction

1.1 Project Overview

Nason Creek is a Category 2 watershed in the Wenatchee subbasin, and contains major spawning areas for Endangered Species Act (ESA)-listed fish, including Upper Columbia River (UCR) spring-run Chinook salmon, UCR steelhead, and Columbia River bull trout. Nason Creek has a high potential to increase salmonid abundance and productivity; therefore, the restoration of ecosystem function in Nason Creek through increasing habitat complexity is a priority for salmon recovery in the Wenatchee watershed (Upper Columbia Regional Technical Team 2008). Past human activities that have affected river processes in Nason Creek include beaver trapping, highway and railroad construction, settlers, logging of riparian forest, clearing of log jams, continued development, and construction of flood protection measures (small levees, bridges, riprap bank protection, and roads). Specifically, ecosystem processes in the Lower White Pine reach (river mile [RM] 9.45 through RM 11.55) are in a degraded state as a result of the removal of the floodplain by the Burlington Northern Santa Fe (BNSF) Railroad grade and U.S. Highway 2 (US 2) and the hardening of the banks with riprap (U.S. Bureau of Reclamation [Reclamation] 2009). The Chelan County Natural Resource Department (CCNRD) has been working with multiple stakeholders to examine means for improving riverine processes and habitat conditions in the Lower White Pine reach to increase salmonid abundance and productivity in the Wenatchee Watershed.

1.2 Study Area

The Nason Creek Lower White Pine Habitat Reconnection Project study area consists of the Lower White Pine Reach as defined by Reclamation and described in the Lower White Pine Reach Assessment (Reach Assessment) (Reclamation 2009). This reach is a 2.1-mile-long segment of Nason Creek between RM 9.45 and RM 11.55, in Township 26 North, Range 16 East, Sections 2, 3, 10, and 11, Willamette Meridian (Figure 1).

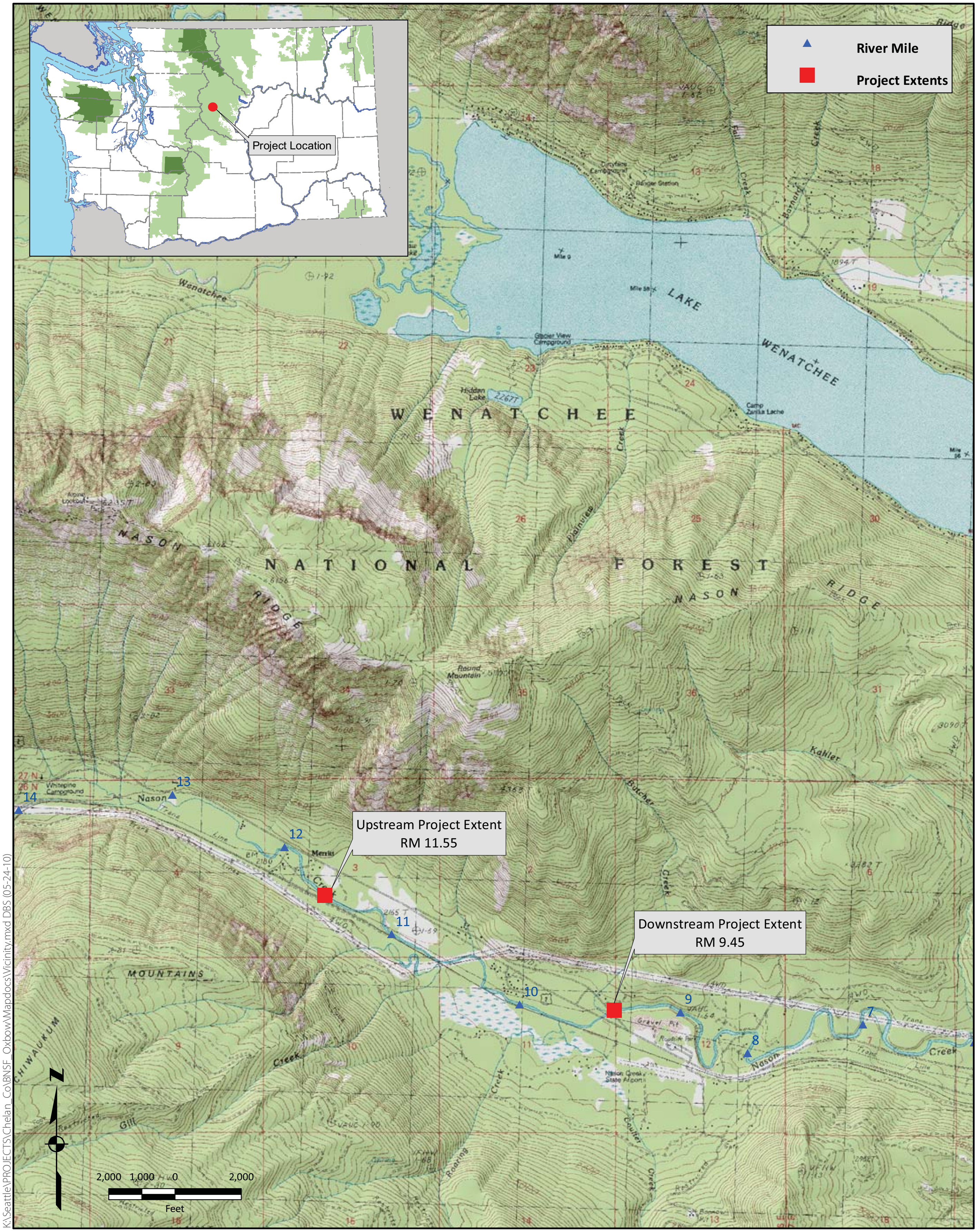

Figure 1. Project Vicinity
BNSF Railway - Nason Creek Alternatives

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Chapter 2
Project Purpose

The existing habitat in Nason Creek has been degraded by several human activities, including US 2 and railroad construction through most of the floodplain in the study area. From RM 4 to RM 14 the channel length has been reduced by 1.5 miles over the past century, mostly where the railroad and US 2 have constrained the channel and floodplain (Reclamation 2008). These activities have reduced lateral migration, erosion, the formation of new channels, and the connection to floodplain surfaces—processes vital for long-term, sustainable ecosystem function. Reduced habitat features in the present system include large woody debris (LWD)-formed pools, backwater areas, side channels, and high-flow refuge areas (U.S. Forest Service [USFS] 2007). These impacts have occurred in the area that supports the second largest spring Chinook salmon spawning population (by redd count) in the Wenatchee Subbasin, along with important steelhead and bull trout populations (Andonaegui 2001).

The primary objective of recommended habitat restoration actions in Nason Creek is to recover long-term sustainable habitat function and availability. This can be accomplished by doing the following (Reclamation 2008; Upper Columbia River Salmon Recovery Board [UCSRB] 2007):

- Increasing the availability and quality of off-channel areas by removing or controlling the breaching of artificial barriers;
- Increasing the complexity of the main channel by increasing in-channel LWD complexes, and restoring riparian habitat and the floodplain reconnection; and
- Reducing high-water temperatures by reconnecting side channels and the floodplain, and improving riparian habitat conditions.

The study area has been identified as having the highest potential for restoration of natural riverine processes and habitat through the modification of human-constructed features (Reclamation 2009). Two large sections of the historic Nason Creek channel and floodplain were disconnected as a result of the construction of the Great Northern Railway in 1893 in this reach and thus provide an excellent opportunity to reconnect historic habitats and riverine processes (Reclamation 2008). These two disconnected channels are labeled as LWP DIZ-1 and LWP DOZ-2, and LWP DIZ-2 and LWP DOZ-4; they are the two largest channel disconnection sites on Nason Creek (Figure 2) and are hereafter referred to as *project sites*.

The reconnection of the two historic channel and floodplain habitats would increase the amount of floodplain accessible to the river by 33%. The 109 acres of historic channel and floodplain habitat that would be reconnected is in a relatively pristine condition and this project has the largest potential to reconnect floodplain processes in the Nason Creek drainage. The completion of this reconnection project would lead to improved salmonid abundance and productivity for multiple ESA-listed species and would reconnect 14% of the Nason Creek drainage basin associated with the Gill Creek, Coulter Creek, and Roaring Creek basins.

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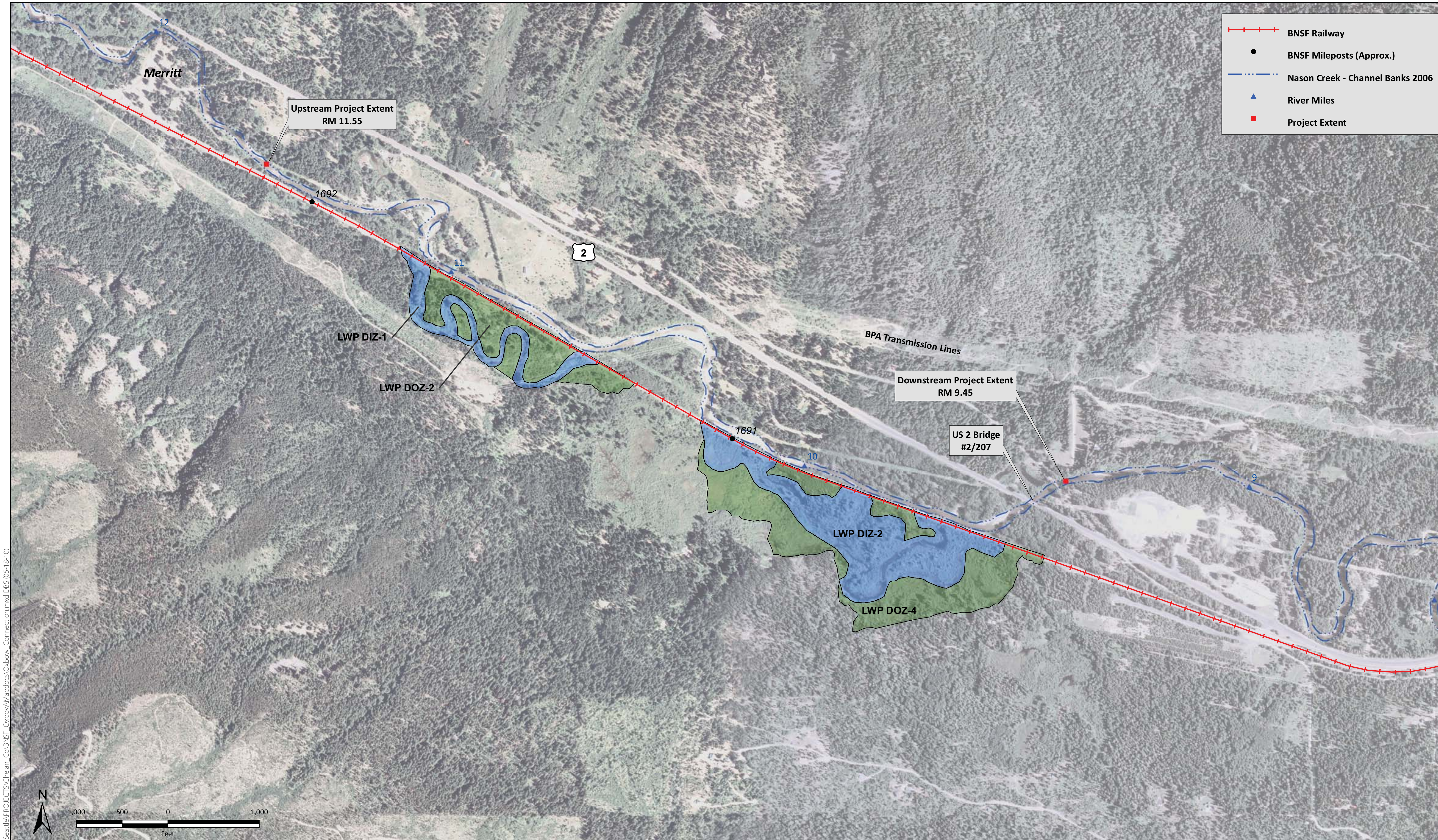

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Figure 2. Study Area
BNSF Railway - Nason Creek Alternatives

Chapter 3
Assessment of the Study Area

A site assessment was conducted within the study area (RM 9.45 through RM 11.55) with the following objectives:

1. Identify, evaluate, and map existing conditions;
2. Evaluate the potential for reconnecting the main channel to the two disconnected channels.

The information and analysis generated during this site assessment is presented below, and was used to evaluate the proposed project alternatives in Chapter 4. A significant amount of background data was provided by Reclamation, most of which was generated and presented in the Nason Creek Tributary Assessment (Tributary Assessment) (Reclamation 2008) and in the Reach Assessment (Reclamation 2009).

The project team conducted site visits on November 12, 2009, and March 29, 2010, to verify and complement the data resources provided by Reclamation. The existing conditions were identified and recorded in the field using the Nason Creek Tributary Assessment Map Atlas (Reclamation 2008), light detecting and ranging (LiDAR)-generated topographic maps (Watershed Sciences 2007), and recent aerial photography (National Resource Conservation Service 2006) as references. Data was then mapped in a geographical information system (GIS). The project team used as much of the data provided in the Tributary Assessment as possible. Please refer to the Tributary Assessment and its appendices for supporting details concerning the background data analysis.

3.1 Site Description

The Lower White Pine Reach study area encompasses about 229 acres of floodplain and active channel. The channel flows west to east, is low gradient (less than 1%), moderately sinuous, and confined primarily by human-made features: the US 2 highway prism to the north, and the BNSF railway prism to the south. Channel constrictions at the upstream end of the study area (BNSF railway fill at the town of Merritt [RM 11.6]) and at the downstream end of the study area (US 2 bridge [RM 9.5]) form the upstream and downstream boundaries of the study area.

Within the study area (RM 9.45 and RM 11.55), Nason Creek exhibits two distinct characteristics:

- stable with quality spawning habitat (RM 9.6 to RM 10.2 and RM 10.7 to RM 11.0); and
- actively meandering (RM 10.2 to RM 10.7 and RM 11.0 to RM 11.5).

The two disconnected channels in the study area are located along historically (post railroad construction in 1893) stable sections of the creek to the south of the BNSF railroad embankment. At both sites, the BNSF railroad grade prevents channel migration into this historic floodplain, which has resulted in the loss of habitat, the impoundment of runoff and groundwater, the impoundment of three named tributary streams (Coulter and Roaring creeks at LWP DIZ-2, Gill Creek at LWP DIZ-1) and several unnamed tributary streams, and a change in vegetation from mixed hardwood to shrub. Both sites have culverts through the railroad embankment only at the historic downstream channel connection (see photos in Appendix A); however, these culverts limit and/or prevent fish access into the wetted habitats behind the railroad grade (Reclamation 2009). Disconnection of the relict channels in the Lower White Pine reach resulting from BNSF channel straightening reduced the reach length by 29%.

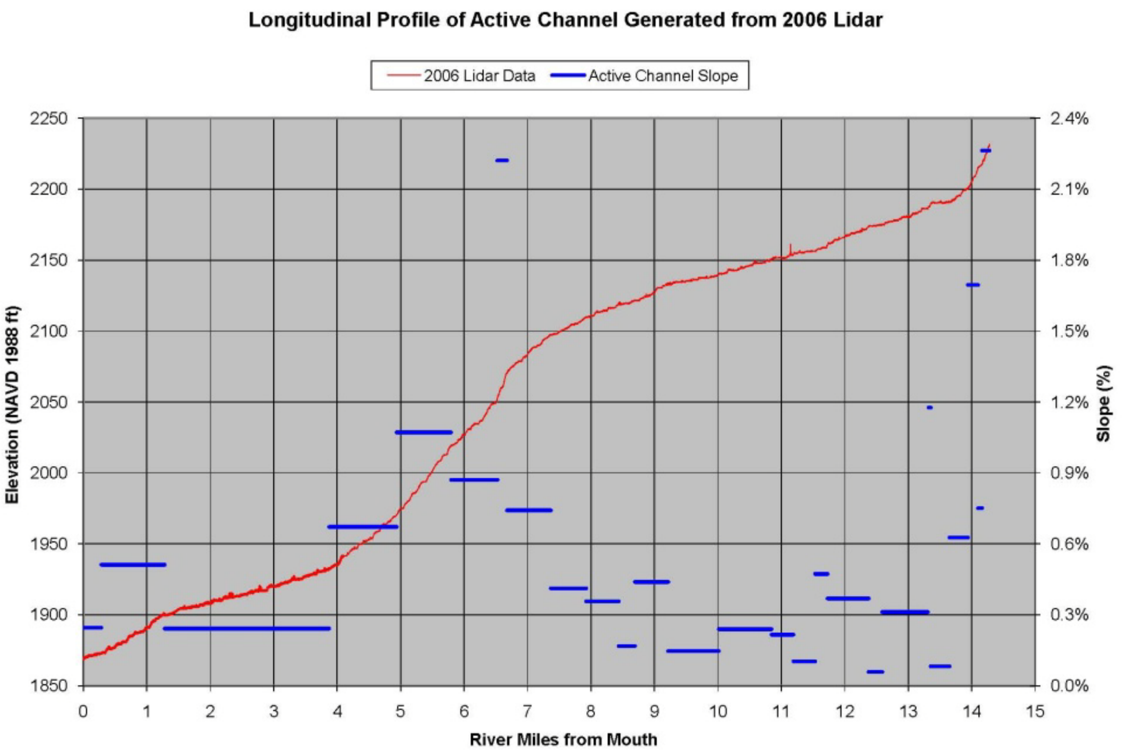
3.2 Geomorphic Characteristics

The geomorphic evaluation of the study area relied on data presented in the Tributary Assessment (Reclamation 2008), accompanying documents such as the Map Atlas provided by Reclamation, BNSF right-of-way maps, Washington State Department of Transportation (WSDOT) bridge scour measurements, and field observations.

3.2.1 Vertical Stability

In the vicinity of the study area, the longitudinal profile of the channel has a relatively uniform, flat slope between 0.1% and 0.5% (Reclamation 2008) (Figure 3). There is a decrease in slope from upstream of RM 13.5 through the study area, and as a result of the change in slope the study area is expected to be a location of increased sediment deposition. This response is also suggested by the increase in fine sediment relative to upstream and downstream reaches (Reclamation 2008).

Figure 3. Longitudinal Profile of Bankfull Slope of Nason Creek (RM 14)

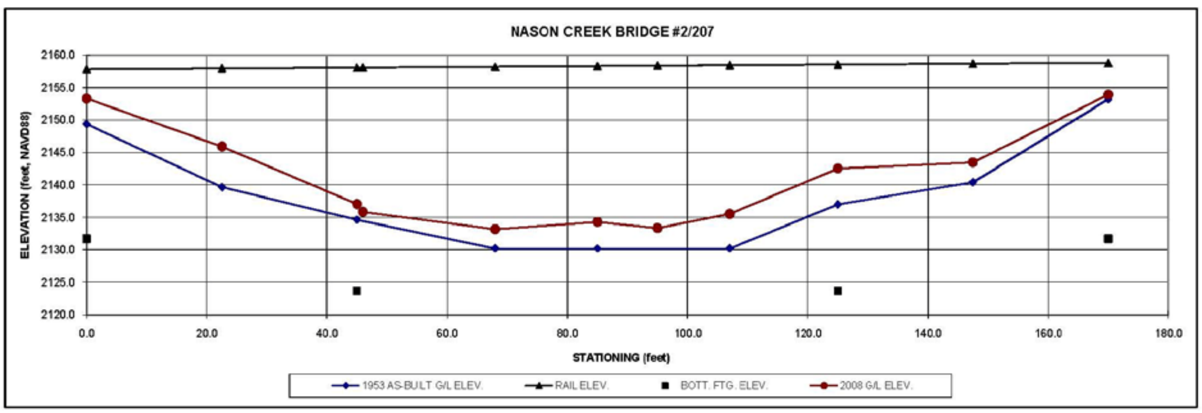


Source: Reclamation 2008

A comparison of cross section thalweg points from a Federal Emergency Management Agency (FEMA) study in the 1980s to a 2007 thalweg profile survey by Reclamation suggests no large changes in channel slope or channel bottom elevation during the last three decades (Reclamation 2008). Using the same 1980s FEMA and 2007 survey data, Reclamation conducted an analysis of potential channel bed scour along the railroad prism. This work indicated that there is not a clear relationship between the location of deep pools and riprap locations at a reach scale. The analysis, however, did suggest that local impacts on channel depth could be occurring. Cross-section comparisons made at locations where the channel has not changed position since the 1980s included a cross section at RM 9.83 (LWP DIZ-2). This showed that only small changes in bar and bed elevations in the main channel have occurred in the past 30 years.

For the purposes of identifying bridge scour related to channel incision, WSDOT periodically measures the channel bed at bridges over streams and compares the measurements to original ground measurements from the time of construction. The US 2 bridge at the downstream end of the study area is a WSDOT bridge, referenced as Bridge #2/207. The most recent channel bed measurement by WSDOT was in 2008. Figure 4 shows a comparison of the original bed elevation to the bed elevation in 2008. The comparison indicates there has been deposition of about 3 feet of sediment at the upstream face of the bridge, where measurements are taken. In the 2007 Reclamation thalweg survey, the nearest point upstream of Bridge #2/207 has essentially the same elevation as the thalweg point in the 2008 WSDOT measurement.

Figure 4. Bridge 2-207 Soundings Comparison 1953 to 2008



The assessment of vertical channel stability does not show channel scour/incision along the study area on Nason Creek over the past 5 decades as is often expected to occur when channels are shortened and steepened by human activities. However, this does not preclude that channel scour/incision has occurred in the past along the study area since construction of the railroad in the 1890s. The incision may have stabilized by the time detailed channel measurements were taken in the 1950s and available for comparison to recent channel bed measurements. Reclamation is currently conducting a ground survey in the study area to examine potential elevational differences between the existing channel and the disconnected channel areas, which may not be accurately conveyed in the 2006 LIDAR data. This topographical survey data will be essential for examining the potential reconnection alternatives discussed in Chapters 4 and 5.

3.2.2 Horizontal Stability

In the vicinity of the study area, geologic controls result in flatter slopes, wider valleys, and greater opportunity for channel migration than in the confined reaches above RM 14 and in the Kahler Reach below RM 9.55(Reclamation 2008). Historically, up to 95% of Reach 3 (which includes the study area) was described as a meandering channel, but now only 37% of Reach 3 is described as meandering (Reclamation 2008). A high rate of lateral migration would be expected in the study area because of the transition in channel slope from steep to flat, and transition in valley width from a confined reach to a reach with more room to meander.

Figure 5 shows the location of the Nason Creek channel in 1939, 1962, 1975, and 2006. The 1939 channel location was digitized from BNSF right-of-way maps. The 1962 and 1975 channel locations were digitized from aerial photographs by Reclamation as part of the Tributary Assessment. The 2006 channel location was digitized from a digital version of an orthorectified 2006 aerial photograph obtained from the Natural Resources Conservation Service; this aerial photo is also the background image in the figure. Given the methods of digitization and sources of data, the channel lines are good approximations of where the channel was but should not be considered exact, except for the professionally orthorectified 2006 photo. The channel locations do offer a good indication of where significant channel migration has occurred during the past 70 years.

As shown in Figure 5, channel migration has primarily occurred at the upstream ends of both disconnected channel sites. Upstream of LWP DIZ-1 between RM 11.5 and RM 11.1, a long meander has moved 1,200 feet since 1975. The future migration of this meander bend downstream is limited due to the location of a house at RM 11.1 and the assumed bank armoring associated with protecting that house. Upstream of LWP-DIZ-2 the apex of the creek's meander adjacent to US 2 has continued to migrate toward US 2 and is now against the highway. As with the upstream project site, the future migration of this meander bend downstream is limited due to the location of a house at RM 10.3 and the assumed protection associated with that structure.

Downstream of LWP DIZ-2 at RM 9.5 the channel was adjusted with the construction of the US 2 bridge in 1953. This constriction to channel migration forms the downstream end of the study area.

Where the railroad and highway have constrained the channel and floodplain, the channel is straight with a minimal diversity in channel geometry. Average channel velocity would be expected to be higher along the straightened channel sections adjacent to the railroad. However, a plot of average channel velocity (Figure 6) using Reclamation's HEC-RAS model indicates that flow velocities aren't consistently different along the straightened areas versus the meandering areas.

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Historic Channel Alignments
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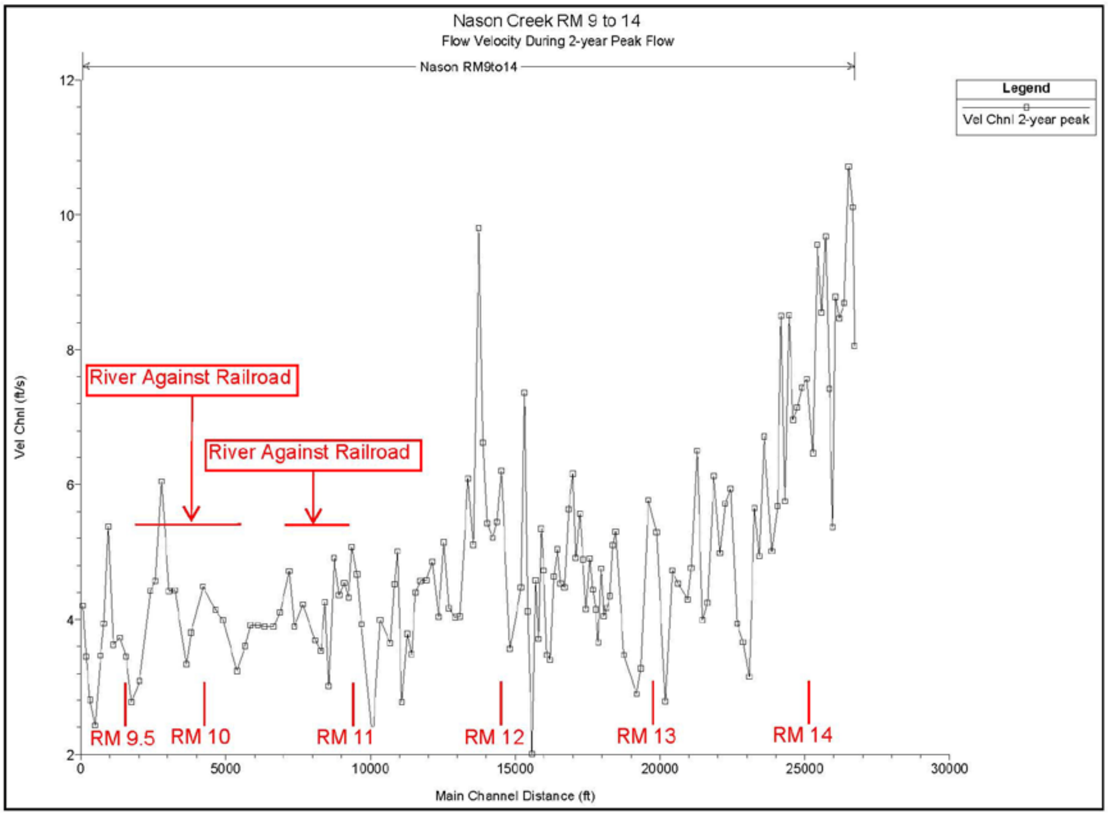
Figure 6. Average Channel Velocities

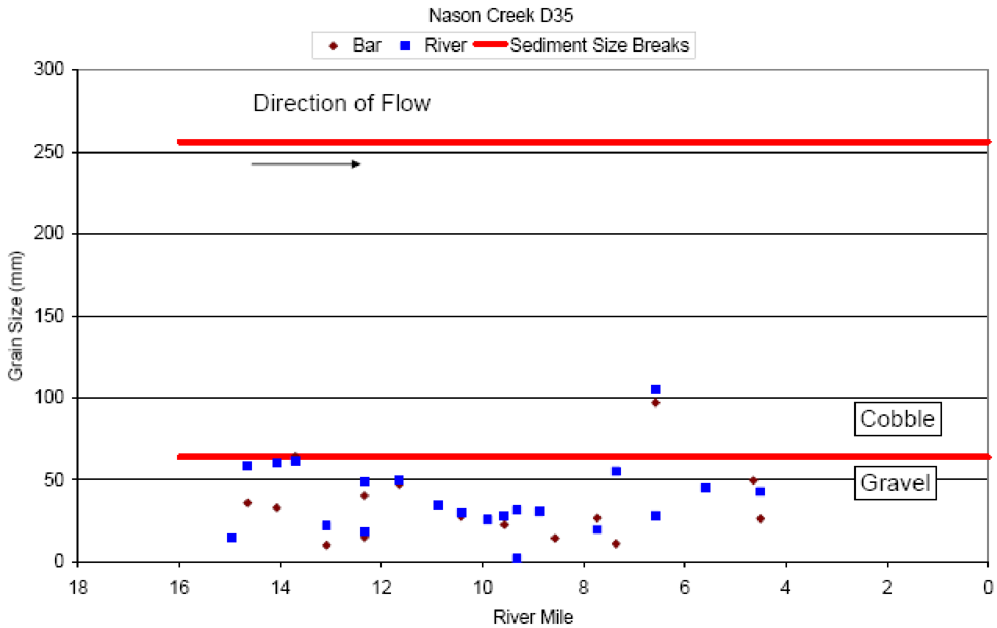


3.2.3 Sediment Transport

Because of the absence of connected tributaries in the vicinity of the study area (Roaring, Coulter, and Gill creeks are disconnected behind the railroad prism), the primary sediment supply to the area is the upper Nason Creek watershed (Reclamation 2008). Mass wasting, tributary inputs, and channel migration all provide a sediment supply that is routed down through the steeper upper watershed channel (Reclamation 2008).

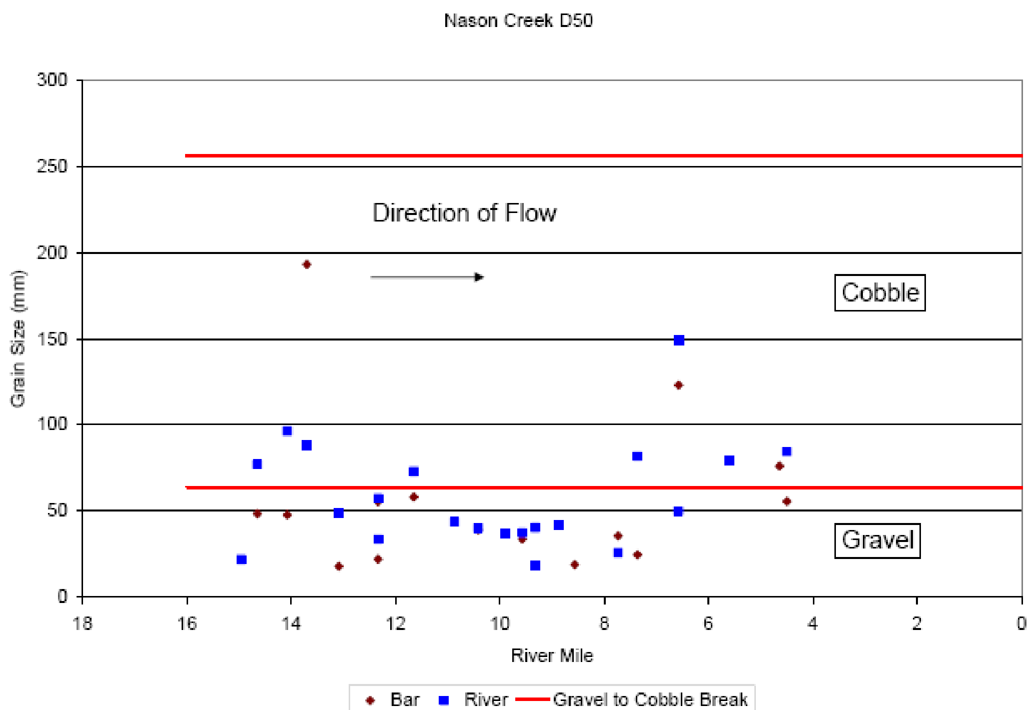
Material delivered from the upper watershed is routed down toward the project reach, where it is deposited due to the decrease in slope. This change in slope is reflected in the decrease in sediment size for the D35 and D50, in the project reach relative to the upper reaches, based upon surface pebble counts completed by the USFS (Figures 7a and 7b) (Reclamation 2008).

Figure 7a. Results from D35 Pebble Counts Error! Bookmark not defined.



Source: Reclamation 2008

Figure 7b. Results from D50 Pebble Counts



Source: Reclamation 2008

Based on incipient motion analysis completed by Reclamation with results from the two-dimensional (2D) model, the transport capacity through the study area appears to be in balance with the available sediment sizes. Nason Creek in the vicinity of the disconnected channel sites is a gravel bed stream with a dominant transport function. This indicates that at times of high flows, bankfull flow and larger, there is a significant amount of bedload transported by the creek.

3.3 Hydrology

The hydrologic analysis of the study area of Nason Creek relied exclusively on the Tributary Assessment (Reclamation 2008) and accompanying documents provided by Reclamation. This discussion summarizes and interpolates Reclamation's work on the project area scale.

3.3.1 Basin Characteristics

Nason Creek is a major tributary within the Wenatchee River watershed, located high in the North Cascades, draining an area of more than 100 square miles. The topography varies substantially, transitioning from steep, mountainous terrain in the headwaters to much flatter terrain lower in the basin. Flows fluctuate seasonally with peak flows driven by spring snowmelt runoff during May through early July and rain-on snow events that occur from November through May. Low flows typically occur during late summer (August through September), once the snow pack has receded (Reclamation 2008).

3.3.2 Flood Frequency

There are 14 U.S. Geological Survey (USGS) gages within the Wenatchee River watershed; however, none are located on Nason Creek. The Washington State Department of Ecology (Ecology) recently installed gage 45J070 near the mouth of Nason Creek at RM 0.8. This gage collected provisional flow data from 2002 to 2010. While the Ecology gage provides useful short-term data, there is uncertainty associated with the quality of the data due to reports of backwater influence during high flows, a limited rating curve, and the provisional nature of the data. Also, the period of record (6 years of data were used in the Reclamation analysis) is relatively short and insufficient for flood frequency analysis (Reclamation 2008).

The Ecology gage data are most appropriately used for characterizing seasonal flow fluctuations and documenting daily flows during non-peak runoff conditions to be used for calibration of the hydraulic model which will be developed at a later time.

The hydrologic analysis included in the Tributary Assessment used the short period of record from the Ecology gage on Nason Creek and a basin transfer analysis, relating data from the long-term USGS gage on Icicle Creek to Nason Creek, to develop a synthetic long-term flow record for Nason Creek. The synthetic flow record formed the basis for a Log-Pearson Type III statistical flood frequency analysis. Peak flow estimates were distributed throughout the basin using a relationship of drainage basin area to runoff developed by comparing the available USGS streamflow gages in the Wenatchee River watershed.

Results of the flood frequency analysis are summarized by river mile in Table 1. The flood flows reported at RM 10 will be adopted for the Lower White Pine study area (RM 9.5 to RM 11.5). Design flows are discussed in more detail below.

Table 1. Flood Frequency Flows at RM 1 through RM 14 on Nason Creek Using a Correlation to Icicle Creek Gage

River Mile	Drainage Area (mi2)	Q2 (ft3/s)	Q5 (ft3/s)	Q10 (ft3/s)	Q25 (ft3/s)	Q50 (ft3/s)	Q100 (ft3/s)
1	108.3	2,500	3,600	4,600	6,000	7,300	8,700
2	107.4	2,400	3,600	4,500	6,000	7,200	8,600
3	105.7	2,400	3,500	4,500	5,900	7,100	8,500
4	103.7	2,400	3,500	4,400	5,800	7,000	8,300
5	99.7	2,300	3,300	4,200	5,500	6,700	8,000
6	98.2	2,200	3,300	4,200	5,500	6,600	7,900
7	94.2	2,100	3,200	4,000	5,300	6,300	7,600
8	93.0	2,100	3,100	4,000	5,200	6,300	7,500
9	92.1	2,100	3,100	3,900	5,100	6,200	7,400
10	78.1	1,800	2,600	3,300	4,400	5,300	6,300
11	74.4	1,700	2,500	3,200	4,200	5,000	6,000
12	71.7	1,600	2,400	3,100	4,000	4,900	5,800
13	70.3	1,600	2,400	3,000	4,000	4,800	5,700
14	67.3	1,500	2,300	2,900	3,800	4,600	5,500

Source: Reclamation 2008
mi^2 = square miles; ft^3/s = cubic feet per second

3.3.3 Historical Flood Events

Documentation of historical floods is based on local knowledge of USFS personnel, a FEMA report, and WSDOT personnel interviewed by Reclamation. The occurrence of historical floods was validated by examining streamflow data available from nearby gages on the Wenatchee River and Icicle Creek, a nearby tributary to the Wenatchee River (Reclamation 2008).

The Tributary Assessment (Reclamation 2008) summarized the following flood events for Nason Creek:

- **1948**: Flood of Record throughout the Upper Columbia Basin. FEMA (2004) noted that USGS estimated 5,270 cubic feet per second (cfs) peak flow at the mouth of Nason Creek. USFS reported that high flows affected the highway.
- **1959**: FEMA (2004) noted that USGS estimated a flow of 6,860 cfs near the mouth of Nason Creek.
- **1980 and 1990**: Rain-on-snow event produced high water flooding around Lake Wenatchee and Nason Creek.
- **1996**: Flood damage along State Route (SR) 207 between Coles Corner and the confluence of Nason Creek. US 2 washed out near RM 13; bank protection including barbs was subsequently placed to protect the road.
- **2008**: The Ecology gage estimated an instantaneous peak flow of 3,150 cfs sometime around May 24, 2008. The published flow rate is provisional (Reclamation 2008).

3.4 Hydraulics

The hydraulic analysis of the study area of Nason Creek relied exclusively on the Tributary Assessment (Reclamation 2008) and accompanying documents provided by Reclamation. This discussion summarizes and interpolates Reclamation's work on the project area scale.

3.4.1 Existing Hydraulic Modeling

Reclamation developed two hydraulic models for Nason Creek (RM 4.6 to RM 14.3), a one-dimensional (1D) model using HEC-RAS and a 2D using SRH-W (v1.1). Both models were developed using the 2006 LiDAR data collected when the creek was flowing at about 40 cfs. The LiDAR data set is considered most applicable for comparing off-channel and floodplain connectivity at near-bankfull and higher flows because the channel bathymetry below the 40 cfs water surface elevation is undefined (Reclamation 2008)

Results from the existing HEC-RAS model provide general hydraulic conditions for evaluating alternative actions at a preliminary level. At a later phase, a detailed hydraulic model will be developed to evaluate the preferred alternative. The detailed model is necessary because the original models were developed for a more generalized analysis of a large portion of the creek. The existing models are useful in identifying potential restoration project sites and providing a general indication of channel and floodplain hydraulics. However, a model with a more detailed definition of ground geometry and with calibration for higher flow events is necessary for the design of a specific project, especially one where diversion of flow is included.

The existing 1D model indicates that flow depth through the study area is typically between 5 and 6 feet during a 2-year peak flow and between 9 and 11 feet during a 100-year peak flow. Flow velocity through the study area is typically between 4 and 8 feet per second during a 2-year peak flow, and 4 and 8 feet per second during a 100-year peak flow. The flow during a 2-year peak was always confined to the channel, while the 100-year peak flow accessed the available floodplain at all cross sections.

3.5 Instream Habitat

Nason Creek supports three species of federally protected salmonids including:

- Chinook salmon of the Upper Columbia River Spring-run Evolutionarily Significant Unit (ESU);
- Steelhead of the Upper Columbia River Distinct Population Segment (DPS); and
- Bull Trout of the Columbia River DPS (Reclamation 2008).

The general timing of the occurrence of these species (i.e., spawning, egg incubation, rearing, and in-migration) for steelhead, spring Chinook salmon, and bull trout is provided in Table 2. Anadromous fish can access Nason Creek upstream to Gaynor Falls at RM 16.9 above the study area.

Table 2. Life History Timing of Steelhead, Spring Chinook, and Bull Trout in Nason Creek

Species Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
STEELHEAD												
Spawning												
Incubation												
Rearing												
In-migration												
SPRING CHINOOK												
Spawning												
Incubation												
Rearing												
In-migration												
BULL TROUT												
Spawning												
Incubation												
Rearing												
In-migration												
Source: Reclamation 2008												

Key:

- Black indicates periods of heaviest use.
- Grey indicates periods of moderate use.
- Blank areas indicate periods of little or no use.

Nason Creek is a Category 2 watershed in the Wenatchee subbasin, which contains major spawning areas for ESA-listed spring Chinook salmon and steelhead, and is a bull trout core area (Upper Columbia River Technical Team [UCRTT] 2008). The Nason Creek drainage supports the second strongest population of spawning spring Chinook in the Wenatchee subbasin (Andonaegui 2001).

Spring Chinook salmon spawning occurs from mid-August through mid-September, with the majority of spring Chinook redds located in the lower 15.8 river miles. A 2005 survey identified 186 redds in Nason Creek. Eggs remain in the gravel until hatching in December, and fry emerge in January/February. Juveniles spend about 1 year in fresh water before smolting and ocean emigration between April and June (Raekes 2008).

Steelhead enter and begin to ascend the Columbia River in June and July. Upstream migration near the Wenatchee River peaks in early September; most adult steelhead have moved into tributary streams by November. Nason Creek steelhead counts averaged 152 redds per year from 2001 to 2005. Juvenile rearing lasts about 2 to 7 years prior to ocean emigration (Raekes 2008).

Bull trout typically overwinter from December to May and migrate upstream to spawning grounds from May to mid-October; adult bull trout migrate back to overwintering habitat from October to December. The Nason Creek bull trout population is depressed and typically has less than 15 redds each year. Spawning occurs within the upper reaches of the watershed, but not at the project reach (Raekes 2008).

Reconnection to floodplains, off-channel habitat, and high flow refugia is a restoration priority in this reach to restore processes that form and maintain channel complexity essential to spawning and juvenile rearing.

Key uses by ESA-listed fish and other species of concern are as follows:

- spring Chinook spawning, rearing, and migration;
- steelhead spawning, rearing, and migration;
- bull trout migration and foraging; and
- coho spawning, rearing, and migration.

3.5.1 Spawning Habitat

Nason Creek, including the study area has been identified as a major spawning area for Chinook salmon and steelhead and bull trout (Reclamation 2008; UCSRB 2007). Good spawning habitat exists throughout the study area for Chinook salmon and steelhead in riffles and glide habitat. Chinook salmon spawning occurs along both creek reaches along the disconnected channel. Historically, this reach likely had high numbers of spawning fish (USFS 2007).

Pebble count data from Reclamation between RM 9.4 and RM 14.3 indicate that the average (D50) sediment size within the river is 54 millimeters (mm), with 84% of the substrate less than 137 mm and 35% less than 38 mm. Chinook salmon prefer substrate between 13 mm and 102 mm in size for spawning, while steelhead prefer substrate between 6 mm and 102 mm. Substrate within this range (6 mm to 102 mm) appear to be abundant within the study area. Substrate embeddedness is low, and fine sediment does not appear to be affecting spawning areas (USFS 2007).

The majority of Chinook salmon redds are located in the lower 15.8 RMs of Nason Creek. Spawning surveys have identified an average of 147 redds per year since 1998. In 2007, 15 Chinook salmon redds were identified in the study area (USFS 2007).

Nason Creek steelhead counts averaged 134 redds per year from 2001 to 2007. The greatest density of redds were observed in a 3-mile reach between RM 10.6 to RM 13.6, accounting for approximately 43% of the redds observed in Nason Creek in 2004, 2005, and 2007.

The Nason Creek bull trout population is depressed and typically has less than 15 redds each year. Spawning occurs within the upper reaches of Nason Creek and its tributaries, but not typically within the study area. Three bull trout redds were observed in Nason Creek between RM 15.8 and RM 20.5 in 2000 above the study area. However, no redds had been observed prior to, or since that time (Reclamation 2008).

3.5.2 Rearing Habitat

Juvenile Chinook salmon and steelhead and bull trout occur in Nason Creek year-round. Overall, fish rearing habitat is limited in the study area due to the lack of off-channel habitat, lack of side channels, and lack of fish hiding cover (e.g., wood) (USFS 2007). Available rearing habitat in the lower study area is limited to the railroad prism riprap, and pools lacking overhead cover.

3.5.3 Large Woody Debris

LWD counts are very low where larger amounts of wood would be expected to accumulate do to the low gradient of the creek (USFS 2007). In addition, wood recruitment is poor due to transmission line vegetation maintenance and due to the disconnection of floodplains from the BNSF railroad prism.

The Nason Creek Watershed Analysis (USFS 1996) documented the potential of LWD recruitment along the channel bank, and LWD that was present in the channel for Nason Creek at the time of the analysis. In summary, from the mouth of Nason Creek to RM 15.4, the outlook for LWD recruitment was categorized as poor. With 75% of this section in private ownership, options to improve this condition are limited. Past human disturbances have changed the character of Nason Creek and severely limited the land’s ability to produce riparian vegetation capable of being recruited as LWD in the future.

3.5.4 Pool Habitat

The reach between RM 9.4 and RM 11.75 (encompassing our study area) consists of 29% riffle and run habitat, 70% pool habitat, and 1% side channel habitat (USFS 2007). Deep pools and spawning gravels are present in the study are despite floodplain impacts from U.S. 2 to the north, the railroad grade to the south, and the Bonneville Power Association (BPA) power line corridor (USFS 2007; Reclamation 2008). The number of pools in this study area is higher than adjacent reaches, however the pools lack complexity. Pools greater than five feet deep were common at wood accumulations and spring Chinook redds were often found in pool crests of deep pools or riffles with wood accumulations (Reclamation 2008).

3.5.5 Side Channel

Very little side channel and off-channel habitat exist in the reach (at low flow) (USFS 2008). One side channel is located in the upper segment of the study area at RM 11.3 but is currently disconnected from the creek at low flows.

3.6 Disconnected Channel LWP DIZ-1 and LWP DOZ-2

The construction of the railroad in 1893 disconnected 31 acres of channel and floodplain habitat along with 4,755 linear feet (0.9 mile) of historic channel of Nason Creek between RM 10.7 and 11.1. The BNSF railroad grade prevents channel migration into this historic floodplain which has resulted in the loss of habitat, impoundment of runoff and groundwater (including Gill Creek and an unnamed tributary), and a change in vegetation from mixed hardwood to palustrine scrub-shrub vegetation. The project site has a culvert within the railroad grade only at the historic downstream channel connection. This culvert is 36 inches in diameter and is a 100% fish passage barrier.

3.6.1 Hydrology

The disconnected inner zone has the potential to provide 11 acres of aquatic habitat. No surface flows from Nason Creek currently enter the old channel. Average width is approximately 50 to 70 feet, and average depth is approximately 3 to 6 feet. The existing channel is wetted for the majority of the year and is impounded by one active beaver dam. The water surface elevation within the old channel fluctuates similarly to the surface water elevation on the mainstem but is higher than those on the mainstem due to impounding from the beaver dam and a perched culvert at the downstream end of the historic channel. The water level in the disconnected channel may be higher than the water level in Nason Creek due to inflow from streams located on the south side of the basin that contribute runoff to the old channel but then are impounded in the area by the beaver dams and perched outlet culvert. The CCNRD is conducting monitoring in 2010 to better determine this relationship.

Gill Creek and an unnamed tributary both input surface flows directly into the disconnected channel. The CCNRD has installed stream gages at both creeks. Observations in the spring of 2010 indicated that these creeks input between 5 and 20 cfs into the historic channel during high spring flows. Recent observations indicate that Gill Creek flow is approximately 50% greater than the flow from the unnamed tributary. These flows combined with surface waters in the channel exit the project site through each of the following:

- the perched 36-inch culvert,
- a channel adjacent and parallel to the BNSF railroad prism, and
- groundwater.

The 36-inch culvert is only effective during spring high flows; it does not carry any flow for the remainder of the year. During a recent high runoff event where Nason Creek and the small tributaries flowing into the ponded area of the old channel were at or above bankfull discharge, the flow out of the culvert and into Nason Creek was estimated to be 2 cfs. The channel adjacent to the BNSF prism directs the majority of flow approximately 1,800 feet downstream and connects directly to surface waters associated with LWP DIZ-2 (See photos in Appendix A). During spring flows in 2010 this connection channel was observed to carry between 10 and 20 cfs.

Gill Creek, the unnamed tributary, and the area within the disconnected old channel represent approximately 4% of the Nason Creek drainage basin.

3.6.2 Existing Habitat

A wetland delineation and assessment of habitats is scheduled for completion in the summer of 2010. The following summarizes findings from reconnaissance work conducted in April 2010.

The majority of habitats in the LWP DIZ-1 and DOZ-2 boundaries are wetlands as indicated on National Wetland Inventory maps (USFWS 2010) and through a field reconnaissance. Wetland habitats classified as using Cowardin et al. (1979) include palustrine forested (PFO), palustrine scrub-shrub (PSS), palustrine emergent (PEM) and palustrine aquatic bed/unconsolidated bottom (PAB/UB) types. The PFO and PSS habitats dominate the historic floodplain directly adjacent to the channel meander. Within the meander PAB/UB habitats dominate fringed by PEM.

Aquatic habitats within the disconnected channels are characterized by muck/silt/sand-filled runs located within the historic channel. Gravel and cobble material from the historic channel bed exists below this silt/muck layer.

In general, the riparian condition is very high, with a variety of trees, shrubs, and grasses present on each bank. All of the tree vegetation is native and includes red alder, Douglas maple, red-osier dogwood, Ponderosa pine, and Douglas fir).

There is one active beaver dam present in the disconnected channel (Figure 8). The beaver dam trapped sediment and impeded flows with a sill drop of about 3 feet at high flows in spring of 2010. Gill Creek enters the disconnected channel immediately below this beaver dam. LWD influence is generally moderate in and near the channel (i.e., on the streambanks). As this channel is cut off from their main channel it has not received the same amount of LWD from upstream sources as the main channel. Most of the LWD disconnected channel is derived from the historic floodplain and is typically situated in the center of the channel.

Gill Creek is a high gradient, step-pool tributary unsuitable for anadromous salmonid use.

3.7 Disconnected Channel LWP DIZ-2 and LWP DOZ-4

The construction of the railroad in 1893 disconnected 78 acres of channel and floodplain habitat along with 5,494 linear feet (1.04 miles) of historic channel of Nason Creek between RM 9.6 and RM 10.2. The BNSF railroad grade prevents channel migration into this historic floodplain which has resulted in the loss of habitat, impoundment of runoff and groundwater (including Roaring and Coulter creeks and several unnamed tributaries), and a change in vegetation from mixed hardwood to PSS and PEM vegetation. There are culverts within the railroad grade only at the historic downstream channel connection. These culverts are side by side and each has a 36-inch diameter.

3.7.1 Hydrology

The disconnected inner zone has the potential to provide 40 acres of aquatic habitat. No surface flows from Nason Creek currently enter the old channel. The average width of the channel is approximately 50 to 70 feet, and average bankfull depth is approximately 3 to 6 feet. The existing channel is wetted for the majority of the year and is impounded by several active beaver dams. It is assumed that the water surface elevation within the channel fluctuates in association with the surface water elevation on the mainstem; however, the input from tributary creeks from the south along with the impounding effect from the beaver dams may have a greater influence on water surface elevation. The CCNRD is conducting monitoring in 2010 to better determine this relationship.

Roaring Creek, Coulter Creek, and several unnamed tributaries input surface flows directly into the disconnected channel. These flows combined with surface waters in the channel exit the project site through the three 36-inch culverts at the downstream end of the project site.

Based on observations during high flow in 2010 Roaring Creek was contributing approximately 40 cfs and Coulter Creek was contributing approximately 15 cfs (the combined flow of the two channels form Coulter Creek at this location) into the greater wetland complex. Additional tributaries were estimated to be contributing approximately 10 cfs at during this same site visit. Interestingly, the culvert outlets at the railroad were estimated to be discharging 30 cfs back to Nason Creek. This indicates that the BNSF railroad prism restricts the exchange of flow between these tributaries and Nason Creek; the excess flow is likely conveyed through groundwater.

Roaring Creek, Coulter Creek, the unnamed tributaries, and the area within the disconnected old channel represent approximately 10% of the Nason Creek drainage basin.

3.7.2 Existing Habitat

A wetland delineation and assessment of habitats is scheduled for completion in the summer of 2010. The following summarizes findings from reconnaissance work conducted in April 2010.

The majority of habitats within the LWP DIZ-2 and DOZ-4 boundaries are wetlands as indicated on National Wetland Inventory maps (USFWS 2010) and through field reconnaissance work. Wetland habitats as classified using Cowardin et al. (1979) include PFO, PSS, PEM and PAB/UB types. The PFO, PSS, and PEM habitats dominate the historic floodplain directly adjacent to the channel meander. Within the meander PAB/UB habitats are fringed by PEM habitats. Aquatic habitats within the disconnected channel are characterized by muck/silt/sand-filled runs located within the historic channel. Gravel and cobble material from the historic channel bed exists below this silt/muck layer.

The disconnected channel has the potential to provide high quality rearing habitat and high flow refugia for juvenile salmonids. Beaver dams are prevalent throughout the oxbow, creating ponds that afford exceptional salmonid rearing habitat (i.e., good in-water and overhead cover, deep water, low water velocity, good food base).

Riparian condition is very high, with a variety of trees, shrubs, and grasses present on each bank. All of the tree vegetation is native and includes red alder, Douglas maple, red-osier dogwood, Ponderosa pine, and Douglas fir. Several active beaver dams and many unmapped historic beaver dams are located within this area (Figure 8). The beaver dams trap sediment and impede flows coming from the LWP DIZ-1 connector channel and tributaries draining into LWP DIZ-2 from the south.

LWD influence is generally moderate in and near the channel (i.e., on the streambanks). Since this channel is cut off from the main channel, it has not received the same amount of woody debris from upstream sources as the main channel. Most of the LWD associated with the disconnected channel is derived from the historic floodplain and is typically situated in the center of the channel.

3.7.2.1 Roaring Creek

Historically, Roaring Creek was likely used by Chinook salmon, sockeye salmon, coho salmon, and bull trout for spawning and rearing. Currently, the creek provides 1.1 miles of spawning and rearing habitat for steelhead (Washington Department of Fish and Wildlife (WDFW) 2010). . At RM 1.1 is a natural point barrier (i.e., a waterfall more than12 vertical feet).

3.7.2.2 Coulter Creek

Historically, Coulter Creek was likely used by Chinook salmon, coho salmon, and bull trout. Today, the creek provides approximately 3.0 miles of suitable spawning habitat for anadromous salmonids. Steelhead have been documented in Coulter Creek, but no redds have been observed (WDFW 2010). At RM 3.0 Coulter Creek intersects USFS Road 6930, which has been identified as a barrier to fish passage. The potential habitat gain upstream of USFS Road 6930 is unknown.

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Figure 2. Site Hydrology & Wetlands
BNSF Railway - Nason Creek Alternatives

Chapter 4
Development of Project Alternatives

The alternatives evaluation analysis is a product of an iterative process with a local design team. A strategy session was conducted on March 3, 2010 with local stakeholders including potential project partners and regulatory agency personnel. A design team was selected at this strategy session to guide project development.

Six project alternatives for each project site of the channel reconnection project sites were developed based on recommendations from the design team during a March 15, 2010, meeting in Leavenworth, Washington. A preliminary alternatives evaluation analysis was conducted by the project team and presented to the design team on April 13, 2010, and to the Upper Columbia Regional Technical Team on April 14, 2010. Meeting minutes are provided in Appendix B.

The alternatives are listed below. A review of Alternatives 1 through 6 was conducted for each project site. Alternative 7 was reviewed as an option to create a connection channel between the disconnected channels.

1. Complete relocation of the creek from its existing channel to the historic channel. This alternative would require 100% of flow in the creek during high- and low-flow conditions to pass through the railroad prism.
2. Divert 80% of the flow through the disconnected channel during times of flood flows, but only divert 20% of the flow through the disconnected channel during summer/fall low flows.
3. Divert 60% of the flow through the disconnected channel during times of flood flows, but only divert 20% of the flow through the disconnected channel during summer/fall low flows.
4. Divert 40% of the flow through the disconnected channel during times of flood flows, but only divert 20% of the flow through the disconnected channel during summer/fall low flows.
5. Divert 20% of the flow through the disconnected channel during all flows.
6. Do not divert flow through the disconnected channel—only connect the disconnected channel to Nason Creek at the downstream end.
7. Create a connection channel between the two disconnected channels with single openings in the BNSF rail prism at upstream and downstream ends.

4.1 Project Goals

To develop a list of potential project alternatives the design team established a set of project goals. The selection of a preferred alternative at each of the two reconnection sites must best meet the following project goals:

1. Maximize biological benefit through addressing biological limiting factors.
    a. Increase stream length through a full creek reconnection into the historic channels.
    b. Increase off-channel habitat for juvenile salmonids targeting high-flow refugia and over-wintering habitat.

c. Increase floodplain connectivity and capacity.

d. Reconnect the Coulter, Roaring, and Gill creek basins to Nason Creek.

e. Create flow-through habitat in the disconnected channels through upstream and downstream connections to maximize benefits to spring Chinook and steelhead populations.

f. Maintain summer low flows in the mainstem.

2. Meet stakeholder and landowner requirements.

   a. Meet BNSF Railway requirements.

      1) Minimize disruption to rail traffic during construction.

      2) Do not damage railbed.

      3) Meet long-term maintenance needs.

      4) Provide structures to accommodate future track expansion.

   b. Meet local landowner requirements.

      1) Maintain summer low flows in Nason Creek mainchannel to maintain riverfront property character.

      2) Do not impair adjacent groundwater wells.

3. Minimize impacts on existing habitat.

   a. Protect existing spawning habitat on mainchannel.

   b. Minimize the placement of temporary and permanent structures in the disconnected channels (access roads, new railbed).

4.2 BNSF Project Elements

The project team has been working closely with BNSF Railway Company representatives since 2007 to develop the disconnected channel reconnection project. BNSF has provided detailed feedback concerning its requirements which the project team has used during the design and evaluation of the project alternatives. The following summarizes the feedback obtained on site and from meetings with BNSF Railway Company personnel.

4.2.1 Overall BNSF Construction Objectives

- Construction methods must maintain railroad traffic. Typical work windows on this BNSF main-line are likely to be less than 8 hours at a time.
- Construction methods must meet the Guidelines for Railroad Grade Separation Projects (BNSF – Union Pacific Railroad 2007).
- Proposed structures will need to accommodate future track expansion. This provision requires either the extension of proposed culverts or the construction of adjacent bridges.
- The settlement of track roadbed must be prevented.

- Prevent features constructed by project from causing erosion or flooding that did not exist prior to construction.
- The need for long-term maintenance must be minimized.

4.2.2 BNSF Maintenance

BNSF will require post construction and annual maintenance and monitoring of the installed structures.

4.2.3 Structures and Construction Methods Considered

The project team considered a number of structure types in order to reconnect flows to the disconnected channel habitats. Structures and construction methods considered include:

- culverts (via open-cut, jack and bore, or pipe ramming),
- multi-span bridges using concrete or steel installed on pile foundations during track work windows, and
- single-span steel bridges on pile cap foundations, with a shoofly track to maintain rail traffic during construction.

Details for each method are provided below.

4.2.3.1 Culverts

Two types of culverts were considered for the 20% partial flow and backwater alternatives because of the size limitations for culverts under the BNSF railway prism. These types included corrugated galvanized steel culverts and precast concrete box culverts. Installation of either culvert type at the project sites is not feasible due to the following:

- Open-cut installation cannot be accomplished within the probable work windows due to the frequency of train traffic and the time necessary to excavate the railroad embankment, place the culvert, and backfill the embankment with proper compaction.
- Jack and bore installation methods can be used for pipes having a maximum 8-foot diameter. This installation method is difficult to accomplish because of the adjacent wetlands on one side of the railroad embankment and the creek on the other side. To jack a culvert through the embankment, a large pit needs to be constructed for the jack to push against with enough force to get the pipe through the embankment fill. Construction of the jack pit would have undesirable impacts on the wetland or creek channel at the downstream connections of both project sites and at the proposed upstream connection of LWP DIZ-2. Jacking a pipe is feasible at the upstream connection of LWP DIZ-1.

In addition to construction constraints, a culvert structure would not meet the hydraulic criteria in section 4.5.2 of Guidelines for Railroad Grade Separation Projects (BNSF – Union Pacific Railroad 2007), which states that the “water surface for a 'low chord' event (50 year flood) will rise no higher than the crown of the culvert or the low chord of the bridge." Using an 8-foot-diameter culvert (the largest size feasible), preliminary hydraulic models indicate that the entire culvert would be flooded if installed with adequate depth to provide for filling of the invert with streambed material to simulate a natural bottom. If a culvert is proposed, the installation method would need to be jack and bore, and would require an exemption from the BNSF hydraulic criteria.

4.2.3.2 Bridges

Three types of bridges were considered for this project:

- a concrete box girder (CBG),
- a steel deck plate girder (DPG), and
- a steel through plate girder (TPG).

Concrete box girder bridges can be used for spans up to 49 feet in length, and can be constructed on pile foundations using a railroad pile driver. This type of bridge structure allows for construction during track work windows, and can be constructed without the need for a shoofly track (although BNSF reserves the right to require a shoofly track for any project on its right-of-way). CBG spans become progressively thicker as span length exceeds 25 feet. With the preliminary hydraulics data it is assumed that span thickness must be less than 30 inches to meet BNSF freeboard criteria.

Spans longer than 49 feet require the use of a DPG or TPG bridges. Construction of these bridges would require the construction of a shoofly track to maintain train traffic during construction. Table3 outlines the bridge structure types considered for this project.

Table 3. Bridge Structure Types

Structure Types	Total Span (feet)
14-14-14; 3-14ft. long x 14"-thick slab spans with center channel	42
14-25-14; 25' center span 20" thick slab spans w/ 14' end spans	53
14-36-14; 36' center span 30" deep concrete box beam w/ 14' end spans	64
14-49-14; 49' center span 42" deep concrete box beam w/ 14' end spans	77
25-150-25; 150' Steel deck plate girder 11.5 ft. beam depth w/ 25' approach spans	200
25-160-25; 160' Steel through plate girder 5' beam depth w/ 25' approach spans	210

4.2.3.3 Shoofly

A shoofly track is a temporary track constructed adjacent to the work area that allows train traffic to pass unimpeded during construction. In the case of the Nason Creek project, the existing track grade is built on a high, narrow fill (prism) suitable for a single track only. A shoofly track would require additional fill which would encroach into the adjacent wetlands.

A shoofly track would be required for any project that requires DPG or TPG. This is owed to the fact that longer spans require larger foundations and larger equipment for installation, which precludes the ability to build these bridges using railroad equipment during track work windows.

4.2.4 Equipment Access

BNSF requires construction of permanent access roads to each end of all new bridges to allow for bridge maintenance and inspection access via highway vehicles (BNSF – Union Pacific

Railroad 2007). No access roads exist on the north side of the railway at either disconnected channel location. An unimproved access road exists on the south side of the railway at LWP DIZ-1 at the upstream connection point. The project team anticipates that permanent access roads would need to be constructed at both project sites to the south of the railway to accommodate construction and future maintenance.

4.3 Bonneville Power Administration Transmission Lines

The BPA Chief Joseph-Snohomish 3 & 4 345 kV transmission line crosses Nason Creek and the BNSF railway at RM 10.65 and railmile 1691.35. This passes directly over the historic downstream connection of the LWP DIZ-1 channel with Nason Creek. The proximity of the conductor lines to the railway prevent the use of pile driving equipment as a construction method, and would impair the ability to use large equipment for future maintenance. Because of this conflict, this location cannot be considered as a connection point for the LWP DIZ-1 project site.

4.4 Description of Project Alternatives

Due to construction constraints associated with work on BNSF Railroad right-of-way (discussed above), only bridges are being considered for the crossing structures that will connect the disconnected channel habitat to Nason Creek. This preliminary assessment used existing information provided by Reclamation and did not include any detailed calculations or hydraulic modeling. This approach should yield sufficient results for the purpose of comparing alternatives, but hydraulic modeling will be required to inform the detailed design of the preferred alternative.

To accomplish Alternatives 2, 3, or 4, a flow-control structure (i.e., sill) would need to be included at the upstream bridge. The flow-control structure would most likely be a rock weir with a low-flow notch. The bridge would be sized to pass the maximum amount of the peak flow that is desired for the specific alternative, and the rock structure would span the entire channel under the upstream bridge. The majority of the rock structure would be set at an elevation high enough to prevent flow from entering the disconnected channel during times of low flow, about 2 to 3 feet higher than the channel thalweg. The rock structure would have a notch in the structure about 10 feet wide and extending down to near the channel thalweg elevation that would allow a small portion of the total flow to enter disconnected channel during low flow conditions. During flood conditions, flow from the creek would spill over the higher elevation portion of the rock structure and enter the disconnected channel reconnected habitat.

The cobbles, gravels, and much of the sand-sized material transported by Nason Creek is transported as bedload and stays in the lower portion of the water column. Since the sill would be set higher than the bed of the river and above the zone where bedload transport occurs, only minimal and small-size bedload material will be introduced into the historic channel. However, the larger span structures associated with Alternatives 2, 3, or 4 would allow some wood material to enter the reconnected habitat.

4.4.1 Alternative 1—Full Channel Reconnection

Immediately downstream of the lower disconnected channel is a highway bridge that crosses Nason Creek (WSDOT Bridge #2/207) (Appendix C). This bridge was constructed in 1952, has a total span of 170 feet, and appears to be functioning well hydraulically. However, the total span of 170 feet is shorter than the floodplain width so the bridge embankments encroach on the creek's floodplain during larger events such as the 10-year and 100-year flood.

Using the highway bridge as a guide, a bridge to allow 100% of the flow during all conditions to pass should be at least 170 feet long, and ideally would be slightly longer to reduce the amount of floodplain encroachment. For conceptual analysis and comparison of alternatives, Alternative 1 proposes the installation of bridges with a 160-foot span and two 30-foot approach spans for a total of 220 feet. Single-span bridges are preferable to minimize the bridge's influence on channel hydraulics and minimize the chance for debris to get caught on intermediate piers.

This alternative assumes the following:

- four breaches in the BNSF track embankment;
- A 160-foot-long clear-span TPG bridge with two 30-foot CBG approach spans to eliminate center piers that would be subject to damage from debris flows (log jams);
- a second set of bridges (twin bridges) to allow for a future second track (required by BNSF);
- a shoofly track;
- a 13-foot-wide access road in addition to the second track alignment;
- excavation of the disconnected channels to increase disconnected channel flow capacity
- Mainstem will require fill to raise the streambed elevation to either convert the habitat to wetlands or side channel.

The probable cost to construct this alternative at each project site is $25 million.

4.4.2 Alternative 2—Diversion of 80% at High Flow and 20% at Low Flow

This alternative would also require bridges with a 200-foot span. This alternative would pass 80% of the peak flow, but would have a control structure (at the upstream bridge) that minimized low-flow passage through it. The control structure would remove some of the conveyance area at lower elevations, and this area would need to be achieved by providing a wide opening at higher elevations where flow was allowed to pass. As a result, the total span required for these bridges would be at least the same and possibly greater than that required for Alternative 1. For the purposes of this analysis, this alternative proposes the installation of bridges with a 160-foot span and two 30-foot approach spans for a total of 220 feet.

The assumptions listed with Alternative 1 also apply to Alternative 2.

The probable cost to construct this alternative at each project site is $25 million.

4.4.3 Alternative 3—Diversion of 60% at High Flow and 20% at Low Flow

This alternative would require bridges with a 150-foot span. This alternative would pass 60% of the peak flow, but would have a control structure (at the upstream end) that minimized low-flow passage through it, so just as in Alternative 2, the opening area would need to be wide to provide sufficient conveyance area. Review of a HEC-RAS model prepared by Reclamation indicates that when flow in the creek is 60% of the rate during the 100-year flood, the channel is slightly more than 100 feet wide. To pass 60% of the flow during the 100-year flood, the bridges would need to be slightly longer than 100 feet. Additional length would need to be added to allow for the area lost from the low-flow control structure, and another 30 feet would need to be added to the length to provide for the side slope of the embankment above the 100-year flood water surface up to the structure. This would lead to a total span of 160 feet.

The assumptions listed with Alternative 1 also apply to Alternative 3.

The probable cost to construct this alternative at each project site is $20 million.

4.4.4 Alternative 4—Diversion of 40% at High Flow and 20% at Low Flow

This alternative would route less of the high flow through the disconnected channel but review of the HEC-RAS model from Reclamation shows that the top width of the existing channel would not be much less at a flow equal to 40% of the 100-year flood than at a flow equal to 60% of the 100-year flood (Alternative 3). While it is possible that a detailed design process would lead to a slightly shorter bridge span, for a conceptual analysis, the structure required for Alternative 4 can be assumed to be the same as the one for Alternative 3: 160 feet total span.

The assumptions listed with Alternative 1 also apply to Alternative 4.

The probable cost to construct this alternative at each project site is $20 million.

4.4.5 Alternative 5—Diversion of 20% at High Flow and 20% at Low Flow

This alternative would pass 20% of the total flow through the disconnected channel at all flow conditions. Based on the performance of culverts installed under SR 207 along Nason Creek downstream of the Lower White Pine project site, diversion of 20% of the flow is likely to be achieved by providing a channel with a 10-foot-wide bottom at about the same elevation as the creek's thalweg. Using side slopes of 1.5:1 on both sides of the channel would provide a trapezoidal opening that increased top width and flow area as the water surface in the creek rose. Based on the 10-foot-wide bottom width, side slopes of 1.5:1, and elevation change between the bottom of the channel and bottom of proposed bridge structure, the total span would be 55 feet. Because debris passage is not a significant concern (since most floating debris would remain in the main channel), the bridges could be multiple span structures. Using a 25-foot center span would allow the intermediate piers to be placed far enough up the side slopes so they would be out of the flow during most flow conditions. The structure assumed for use with this alternative is a 25-foot span CBG bridge on steel piles, with two 15-foot CBG approach spans.

This alternative assumes the following:

- four breaches in the BNSF track embankment;
- multiple single-span bridges with center piers;
- a second set of bridges (twin bridges) to allow for a future second track;
- a shoofly track;
- excavation of the disconnected channel to increase disconnected channel flow capacity; and
- a permanent, continuous access road built along the alignment of the twin bridges on 20-foot centers from the existing track centerline.

The probable cost to construct this alternative at each project site is $5 million.

4.4.6 Alternative 6—Downstream Connection Only

This alternative only provides connection between the disconnected channels and Nason Creek at the downstream ends of the disconnected channels. For hydraulic purposes, bridges with a combined 55-foot span, the same size as used for Alternative 5, would provide a good connection throughout the entire range of flows on the creek. Due to the fill height and preference to keep the side slopes of the opening no steeper than 1.5:1, a span smaller than 55 feet is not recommended. The structure assumed for use with this alternative is a 25-foot span CBG bridge on steel piles, with two 15-foot CBG approach spans.

The assumptions listed with Alternative 1 also apply to Alternative 6.

The probable cost to construct this alternative at each project site is $3.7 million.

4.4.7 Alternative 7—Connector Channel

This alternative provides an upstream inlet in LWP DIZ-1 and a downstream outlet in LWP DIZ-2 with a construction connection channel between the two disconnected channels.

This alternative assumes the following:

- two breaches in the BNSF track embankment;
- multiple single-span bridges with center piers;
- a second set of bridges (twin bridges) to allow for a future second track;
- a permanent, continuous access road along the alignment of the twin bridges on 20-foot centers from existing track centerline;
- the access road to be built along the alignment of the twin bridges on 20-foot centers from existing track centerline; and
- connected historic channels on the south side via excavation for flow from LWP DIZ-1 and DOZ-2.

The probable cost to construct this alternative at each project site is $8.5 million.

4.5 Design Elements—Nason Creek LWP DIZ-1 and LWP DOZ-2

Examination of this project site revealed several design elements:

- BPA transmission lines at the downstream connection point prevent structure installation.
- An existing BNSF access road extends from Merritt to upstream connection points. This road would need to be improved or extended to reach the downstream connection points.
- The risk of channel migration at the upstream end results in moving 60%, 40%, and 20% upstream inlets downstream of the historic connection.

The following describes the rationale behind the selection of upstream inlet and downstream outlet connection points.

4.5.1 Evaluation of the Upstream Inlet Connection Point

Two connection points are proposed for the upstream inlet connection. For the 100% and 80% flow connection alternatives the connection point is located to accommodate direct flows from the creek into the disconnected channel at BNSF MP 1691.76 (the midpoint of the connection).

For partial flow connections (60%, 40%, and 20%) the inlet is located downstream at BNSF MP 1691.69. This location was chosen because it is in a location where the channel is more stable and likely to provide the same hydraulics for a long time in the future as would be provided on the day of construction without requiring maintenance. Additionally the partial flow connection point is located where the flow in the creek is not directed at the opening but rather the main creek flow is sweeping past the opening, which will assist in keeping the opening clear of floating debris.

4.5.2 Evaluation of the Downstream Outlet Connection Point

The disconnected channel currently discharges back into Nason Creek at culverts located at BNSF MP 1691.35. This point is located underneath the BPA Chief Joseph-Snohomish 3 and 4, 345 kV transmission line. BNSF requires a minimum of 45-foot clearance of equipment from transmission lines during construction and for future maintenance. The design team looked at alternate construction methods for use under the power lines (bridge with spread footing to avoid pile-driving, or jack and bore pipe/box culvert); however, in all cases a crane would be required. Cranes would be needed to set a bridge, and for culverts cranes would be needed to set the jacking pit and place the pipe or box culvert section. For future maintenance a crane with a claw would be needed to clean out the culvert intake or bridge during a flood.

Based on the proximity of the BPA transmission lines to the existing disconnected channel, installation of a new structure at that location is not feasible. The project team recommends a location approximately 700 feet upstream of the existing culverts at MP 1691.35 as a reconnection point. This location has several advantages:

- There are no conflicts with BPA transmission lines.
- It can accommodate a full channel and all partial channel reconnection alternatives.

- It can take advantage of an existing access road (with improvements) for equipment during construction.

4.5.3 Evaluation of the Connector Channel

The lower end of the existing channel has a connector channel that takes flows from this project site downstream to LWP DIZ-2. As this channel runs directly adjacent to the BNSF railway prism we recommend the construction of a new channel outside of BNSF right-of-way as part of Alternative 7. The low floodplain in between the two project sites provides a good opportunity to excavate a new channel.

4.6 Design Elements - Nason Creek LWP DIZ-2 and DOZ-4

Examination of this project site revealed several design elements:

- There are no existing access roads. A permanent access road would be required and would result in impacts on existing wetland resources.
- The downstream outlet is proposed to the east of the existing culverts to 1) provide better equipment access; and 2) better align the outlet flows with the mainstem of Nason Creek. The existing culverts may remain without impact on the project success.
- A risk of channel migration at the upstream end results in moving 60%, 40%, and 20% upstream inlets downstream of the disconnected channel.

The following describes the rationale behind the selection of upstream inlet and downstream outlet connection points.

4.6.1 Upstream Inlet Connection Point

Two connection points are proposed for the upstream inlet connection. For the 100% and 80% flow connection alternatives the connection point is located to accommodate direct flows from the creek into the disconnected channel at BNSF MP 1691.55 (midpoint of connection).

For partial flow connections (60%, 40%, and 20%) the inlet would be located downstream at BNSF MP 1691.04. This location was chosen to because it is where the channel is more stable and likely to provide the same hydraulics for a long time in the future as would be provided on the day of construction without requiring maintenance. Additionally the partial flow connection point is located where the flow in the creek is not directed at the opening but rather the main creek flow is sweeping past the opening, which would assist in keeping the opening clear of floating debris.

4.6.2 Downstream Outlet Connection Point

For 100% and 80% flow connection alternatives, the location of the downstream connection was selected to orient the momentum of the flow returning from the disconnected channel to the existing channel to be similar to existing conditions. This would reduce the risk of changing channel characteristics near the US 2 bridge and would thus reduce the risk of impacting the bridge.

For the lower partial flow connection alternatives, the location of the downstream connection was selected to also orient momentum of the flow returning from the disconnected channel to the existing channel, and to minimize excavation of a connector channel from the historic channel to the connection structure.

Chapter 5
Alternatives Analysis

Evaluation criteria were developed to select a preferred alternative. The evaluation criteria were selected combining guidance from the Project Rating Criteria in the Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region (UCRTT 2008) and based on the project goals (Chapter 4) developed by the design team.

Each alternative was evaluated or assessed on the following criteria:

- the ability to address biological-limiting factors
- the risk to existing habitat,
- feasibility of construction,
- landowner acceptance, and
- construction cost.

Each of the alternatives was evaluated against the evaluation criteria above and the goals listed in Chapter 4. The results of this analysis are summarized in Appendix D. Concept plans for each alternative are provided in Appendix E.

Based on the results of the alternatives analysis the design team has recommended a more detailed analysis of the Connector Channel Alternative and Alternative 6 at LWP DIZ-2, representing the backwater alternative.

5.1 Description of the Preferred Alternative

Alternative 7, the Connector Channel Alternative, was chosen by the design team as the preferred alternative because it would best provide fish access to off-channel habitats while having the lowest combined project cost and impacts on existing resources. Alternative 6 at LWP DIZ-2 was selected as an alternative that needs further examination because it provides an economical method for reconnecting off-channel high-flow refuge and habitats and provides for the reconnection of Coulter, Roaring, and Gill creek basins.

5.1.1 Alternative 7 (Preferred Alternative)

The Preferred Alternative would:

- Require that the inlet and outlet locations be the same as the upstream inlet proposed for the 20% connection at LWP DIZ-1 and the downstream connection at LWP DIZ-2.
- Require new access roads through wetlands but would greatly reduce the need for access road construction compared to Alternatives 1 through 5.
- Reconnect 109 acres of aquatic and floodplain habitats.
- Require the excavation of approximately 2,000 linear feet of connection channel between the two disconnected channel sites through wetland habitats.

- Reduce the need for four bridge structures associated with the standalone reconnection alternatives.
- Provide flow-through habitats targeting the biological needs of listed juvenile salmonids.
- Provide high-flow refuge and access to off-channel foraging habitat.
- Reconnect 14% of the Nason Creek drainage basin through the reconnection of Roaring, Coulter, and Gill creek basins.

Continued design refinement of the alternative is needed to determine the following:

- Existing hydraulic connectivity between LWP DIZ-1 and LWP DIZ-2.
- Hydrologic contribution on a year-round basis of the Roaring, Coulter, and Gill creek basins.
- Appropriate structure sizes at both upstream and downstream locations.
- Connector channel location and geometry.
- Potential impacts on existing water surface elevations following the reconnection and corresponding impacts on adjacent groundwater elevations,

5.1.2 Alternative 6

In summary, Alternative 6 at LWP DIZ-2 would:

- Reflect the same outlet location as the Preferred Alternative connection at LWP DIZ-2.
- Require new access roads through wetlands but would greatly reduce the need for access road construction compared to Alternatives 1 through 5.
- Reduce the need for six bridge structures.
- Reconnect 109 acres of aquatic and floodplain habitats.
- Provide flow-through habitats targeting the biological needs of listed juvenile salmonids.
- Provide high-flow refuge and access to off-channel foraging habitat.
- Reconnect 14% of the Nason Creek drainage basin through the reconnection of Roaring, Coulter, and Gill creek basins.

Continued design refinement of the alternative is needed to determine:

- Hydrologic contribution on a year-round basis of the Roaring, Coulter, and Gill creek basins.
- Appropriate structure size at the downstream connection.
- Potential impacts on existing water surface elevations following reconnection and corresponding effects to adjacent groundwater elevations,

Continued examination of the Preferred Alternative should attempt to answer questions of risk and assess the certainty of success. The single-connection approach associated with Alternative 6 at LWP DIZ-2 provides a low-risk approach to reconnection and could be considered a first phase (Phase 1) to the Preferred Alternative. Pre- and post-project monitoring of hydraulics, hydrology, and fish use after the construction of Alternative 6 would inform the need to continue to Phase 2 and the construction of an inlet and connector channel.

Chapter 6
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Appendix A

Site Photographs

Photo 1. DIZ-1 inlet near connection point facing downstream.

Photo 2. DIZ-1 outlet culvert side 3.

Photo 3. DIZ-2 outlet river side culverts.

Photo 4. DIZ-2 beaver dam at the downstream outlet.

Photo 5. DIZ-2 inlet location facing downstream 2.

Photo 6. DIZ-2 inlet upstream view.

Photo 7. DIZ-1 inlet location.

Photo 8. DIZ-2 BPA power lines over historic outlet location.

Photo 9. DIZ-2 outlet location facing BNSF prism on creek side.

Photo 10. DIZ-2 ponded habitat.

Photo 11. Existing connector channel.

Photo 12. Existing connector channel 2.

Appendix B

Design Team Meeting Minutes

Meeting Minutes

Date: March 15, 2010

To: Mike Kane

From: John Soden, Martin Fisher, ICF International

Jeff Colon, Hanson Professional Services

cc: Steve Kolk, Reclamation

Subject: Nason Creek Lower White Pine Reach Oxbow Reconnection, Wenatchee Subbasin, WA – Design Team Meeting

Leavenworth Fire Station, Leavenworth, WA

Attendees: Brendan Rogers (YN), Amee Rief (USFS), Steve Kolk (USBR), Mike Kane (CCNRD), David Morgan (USFWS), Mary Jo Sandborn (Chelan Co), John Soden (ICF), Martin Fisher (ICF), Jeff Colon (Hanson), Ken Bevis (WDFW), Chris Fisher (CCT), Kate Terrell (USFWS), Ben Lenz (Grant Co PUD)

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1) Agenda

- Define Project Goals
- Review Potential Project Alternatives

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2) Project Goals

a) Maximize Biological Benefit

i) Increase stream length?

ii) Increase off-channel habitat (primarily for juvenile salmonids)

iii) Increase floodplain connectivity

1108 11th Street, Suite 301♦ Bellingham, WA 98225 ♦ Tel. 360.255.2920 ♦ Fax 360.255.2924
www.icfi.com

iv) Options:
   (1) “Reconnect the channel” as main goal. Work from there.
   (2) Make current main channel into the off-channel. Would maintain riverfront to existing property owners.

v) Limiting Factors:
   (1) Chelan County may not have the ability to buy-out riverfront property (as may be needed for full-channel restoration option).
   (2) Construction Access & Staging
   (3) Long Term Maintenance
   (4) Cost; Project Financial Limit?
      (a) Per Steve Kolk, the extreme case would be to use all of the available upper Columbia Salmon Recovery money allocated for one year; approx. $22M.

vi) Minimize impacts to existing habitat
   (1) Changes to sediment transport within existing channel
   (2) Movement of the channel over time – channel could eventually move past the connection points.
   (3) Juvenile Overwintering
   (4) High flow refugia
   (5) Summer water temperature (thermal regime)
   (6) Changes to groundwater flow & elevation.

vii) Comments:
   (1) David Morgan: “If we can afford it, we want to connect both ends.”
   (2) Martin Fisher – recommends a cost-benefit analysis.
   (3) (unknown) “How much do we want to “siphon off” from the main channel.

b) Meet Landowner Objectives

i) BNSF :
   (1) Mike Cain, Mike Kaputa, John Soden, and Jeff Colon met with Terry Finn & Todd Kuhn of BSNF on 3/12/2010 .
   (2) Summary of BNSF Meeting:
      (a) BNSF prefers bridges constructed by their crews (as opposed to culverts installed by a contractor). This is for operational reasons (single mainline with limited access).
      (b) BNSF crews would drive piles through the existing grade using a rail-mounted pile driver, then, would cut the track, install the bridge, and restore railroad traffic.
      (c) Bridges for a second (future) track are required as part of the project cost.
      (d) BNSF would hire a contractor to install a bridge for a second track since they could not reach the pile locations from the existing track with their pile driver.

(e) BNSF would likely establish easements with Chelan County for maintenance of the stream beds at the proposed undercrossings.
(f) Mitigation fees for ongoing bridge maintenance and inspection would be required (currently there are no bridges and no bridge maintenance costs). These fees are not yet determined and would depend, in part, on the types and number of bridges installed.
(g) BNSF is interested in extending the existing siding at Merritt.

ii) Private Landowners
iii) USFS
iv) Bonneville Power
v) Yakima Nation
vi) Future Fish Hatchery Site west of RM 9.6 on north side of railroad

c) <u>Flow discussion</u>
   i) Main question is to decide how much flow to restore, and what flow breakpoints to consider for options analysis.
   ii) Base flow is approximately 25 CFS
   iii) "Flushing flows" should be considered. Without flushing flows, beavers could block-up the whole site.
   iv) Culverts longer than 100 ft. are discouraged in terms of fish passage
   v) If only a partial reconnection alternative is selected then pull a maximum of 20% of low flow into the oxbow in order to maintain year-round connectivity and fish access while keeping as much water in the main channel.

3) Alternatives
   a) Upper site vs. lower site
   b) Matrix of Alternatives:

4)

		Diz-2		Diz-2	
		Pros	Cons	Pros	Cons
Alternative	Description				
1	100% Flow	(1) Maximum biological benefit.	(1) Impacts listed species spawning on mainstem; (2) initial sediment flushing of oxbow may impact existing spawning gravels downstream (3) upset landowners (4) Water table impacts (5) River continuum – river will move (6) Cost	Same as DIZ-2	Same as DIZ-2
2	80% Flow (80% high flow; 20% min. low flow)[1]	(1) off channel habitat reconnection; (2) improved floodplain capacity; (3) improved spawning habitat in oxbow.	(1) Impacts listed species spawning on mainstem; (2) initial sediment flushing of oxbow may impact existing spawning gravels downstream (3) upset landowners (4) Cost	Same as DIZ-2	Same as DIZ-2
3	60% Flow (60% high flow; 20% min. low flow)[1]	(1) off channel habitat reconnection; (2) improved floodplain capacity;	(1) Impacts listed species spawning on mainstem; (2) initial sediment flushing of oxbow may impact existing spawning gravels downstream		

4	40% Flow(40% high flow; 20% min. low flow)[1]	(1) off channel habitat reconnection; (2) improved floodplain capacity;			
5	20% Flow(20% high flow; 20% min. low flow)[1]	(1) off channel habitat reconnection; (2) improved floodplain capacity.	(1) Impacts listed species spawning on mainstem; (2) initial sediment flushing of oxbow may impact existing spawning gravels downstream	Same as DIZ-2	Same as DIZ-2
6	Groundwater-Charged channel (outlet only)	(1) Might be most viable	(1) May not address stream process & floodplain connectivity.	Same as DIZ-2	Same as DIZ-2
7	Make existing channel the high flow channel (use sill to control flow to south side).		(1) affects landowners on river side.	Same as DIZ-2	Same as DIZ-2

[1]Trapezoidal weir used to control the split in flow.

a) Comments:
   i) River Mi 10.9 – fish like to spawn there due to groundwater flow from ditch (visible as diagonal line on aerial photo).
   ii) Low flow influence of new structures.

5) Action Items:

a) ICF – Send out monitoring information from Nason Creek site.
b) Hanson – Provide probable costs to ICF for alternatives (draft PPT from John issued 4/9)

c) Scheduled Items:

4/9/2010	Fri.	ICF/John to issue a draft Power Point of alternatives analysis for use at meetings on 4/13 and 4/14.
4/13/2010 (13:00)	Tues.	Technical Committee Meeting (prep. For RTT meeting)

4/14/2010 Wed. RTT meeting.

6) Adjourn Time (full meeting): 15:45

7) <u>Handouts & References used at meeting:</u>

a) Aerial Photo : Figure 13, Subreaches priorities using the strategy from Roni, 2006, From *Lower White Pine Creek Reach Assessment (p. 26).*

b) *Nason Creek Habitat Assessment From the Bend at RM 4.6 to the Railroad Bridge Crossing at RM 14.2. Survey Dates September 17 to 19, 2007 and September 24 and 25, 2007*. Prepared by Dave Hopkins and Cameron Thomas, Okanogan-Wenatchee National Forest, October 15, 2007. Reviewed and Finalized by Cindy Raekes, Okanogan-Wenatchee National Forest, May 28, 2008. (Hard copies were available at the meeting).

Meeting with Steve Kolk, 3-15-2010 (16:00- 16:20)

Subject: Survey & Geotech Funding Meeting

Attendees: Steve Kolk, Bureau Reclamation; John Soden, ICF; Martin Fisher, ICF; Jeff Colon, Hanson Professional Services Inc.

1) Jeff Colon, Hanson has provided detailed BNSF safety protocols for all personnel on site, including ICF, geotech, drilling staff, survey crew, agency representatives, Hanson, other contractors hired by Reclamation or CCNRD that are required to meet both BNSF and FRA safety requirements. See attached.

2) **Geotech Scope**
   a) Borings from the top of railroad prism extending down a minimum of 45'. A total of 8 borings, 2 at each proposed opening field located by engineer (Hanson) to coincide with expected pile locations.
   b) Field classification of soil at minimum 5' depth intervals.
   c) Report that identifies the locations of the borings, describes the soils encountered throughout each boring and elevation of groundwater in each boring.

i) Summary of Field Explorations
ii) Summary of Geologic and Seismic Setting
iii) Surface and Subsurface Conditions
iv) Seismic Considerations (including liquefaction considerations, seismically induced settlement, Lateral Spreading)
v) Foundation Recommendations
    (1) Allowable Pile Capacities
    (2) L-pile parameters (both static and dynamic), soil design parameters
    (3) Driven pile recommendations
    (4) Anticipated settlement
vi) Temporary Excavations & Shoring Considerations
    (1) Allowable stable slopes during construction
    (2) Sheet piling considerations
    (3) Soldier pile and lagging considerations
vii) Permanent Embankment Slopes (allowable final stable slopes)

d) Note that there may be utilities buried in the railroad fill, a utility locate will be coordinated by the engineer and performed immediately prior borings.

3) Topo Survey:

a) <u>Discussion Items:</u>
   i) Use existing HEC-RAS model (probably OK for 10-20% flow alternative), or
   ii) Create new 2D model, requiring better survey and recalibration by Reclamation staff
   iii) 2D model determined to be best option for purposes of this project.

b) <u>Survey Scope:</u>
   i) Required Items

   ii) All work done in: horizontal datum = NAD83 State Plane North, vertical datum = NAVD88

   iii) Topo survey of railroad prism and creek channel for area shown on figure (we'll need to make a figure to go along with this that shows the extents, basically take the existing aerial photo figure and modify the red circles). Topo of railroad prism shall extend at a minimum from toe of embankment slope along south side, top of embankment fill, down to toe of embankment slope along north/creek side. Topo of creek channel shall extend at a minimum from 1 foot above water surface on the day of survey along the south/railroad embankment side of channel, through wetted creek channel to 1 foot above water surface along north side of channel. Topo shall be done to level of detail necessary to create contour map with 1 foot interval elevation contours.

iv) Locate overhead high tension wirelines; will have to be done with total station in reflectorless mode or similar method; need height from top of tie to bottom of wireline where it crosses the tracks, record temperature at time of survey, identify limits of overhead powerlines with respect to the railroad tracks below

v) Spot elevations shall be taken at: top of each rail at maximum spacing of 800 feet through area identified for topo survey, top of tie at each centerline of each proposed opening, and upstream and downstream inverts of all culverts within the area identified for topo survey.

vi) Planimetric features within the area identified for topo including: Rails, culverts, edge of water at the time of survey, above ground utilities, any identified/painted below ground utilities, and trees with dbh greater than 6"; and the point of switch at Merritt which is outside the area of the topo survey.

vii) Cross sections through the oxbow area south of the railroad prism. At locations identified on the figure, 12 total. Extend from top of railroad prism to south end of lines shown on figure. Cross sections shall include points at all significant grade breaks with a maximum spacing of 50 feet between points.

viii) Deliverable: File in AutoCAD format that includes all survey points, digital ground surface definition, ground contours at 1 foot interval, spot elevations at locations specified above, linework for planimetric features with each unique feature type on a unique layer in the drawing file, and cross sections of the 12 surveyed cross sections drawn at a 1:1 horizontal to vertical scale.

4) Optional Item

i) Topo survey of oxbow channel south of the railroad at locations shown on the attached figure. Topo shall be done to level of detail necessary to create contour map with 1 foot interval elevation contours.

ii) Deliverable: File in AutoCAD format that includes all survey points, digital ground surface definition, and ground contours at 1 foot interval.

b) Other:
(1) Surveyors will need to meet BNSF safety requirements
(2) David Evans & Associates (DEA) is the Bureau's surveyor)

5) Action Items - Survey
(1) ICF get survey scope to Bureau of Rec. (Steve Kolk)
(2) Jeff Colon to coordinate utility locates to coincide with topo survey.

6) **Adjourn Time** 16:20 (Steve Kolk meeting)

BNSF – Nason Creek LWP Reconnection
Design Team Meeting
April 13, 2010

Attendees:
Mary Jo Sanborn, CCNRD
Robes Parish, USFWS
Kate Terrell, USFWS
Casey Baldwin, WDFW
Gina McCoy, WDFW
Mike Knutson, USBR
Amee Rief, USFS
Brandon Rogers, YN
Steve Kolk, USBR
Mike Kane, CCNRD
John Soden, ICF
Derek Van Marter, UCSRB

Summary: the design team reviewed all of the alternatives at each oxbow location (upstream and downstream) and decided to continue to develop the new alternative presented – the Mega Oxbow would use the upstream oxbow inlet and the downstream oxbow outlet. The two oxbows would be connected with a 2,000 foot constructed channel. This alternative will be presented to the RTT for input. See next steps at the end of the notes.

Notes:
Mike and John went through a power point presentation that summarizes the alternatives identified at the last Design Team meeting (contact Mary Jo for the ppt). There was a recap from the previous DT meeting on project goals (address limiting factors, meet landowner needs, minimize impacts), summarizing the proposed actions and identifying the six alternatives proposed at each site.

At the March meeting, the group decided to have the consultants explore six alternatives at each site (upper reconnection and lower reconnection) based on flow:

100% high, 100% low
100% high, 20% low
80% high, 20% low
60% high, 20% low
40% high, 20% low
20% high, 20% low
Backwater connection only

There was discussion as to why the low flow was consistently 20%. People were not sure where that number came from or spending much if any time discussing it at the previous design team meeting. Could it be higher?
There was an assumption made previously that less than 80% of the low flow in the current channel would be unacceptable to landowners. This assumption has not been verified. Another factor was sediment transport, modeling might indicate that more or less low flow would be acceptable for transporting sediment.

**The group decided to look at varying low flow combinations once we get the high flow alternatives narrowed down, modeling for sediment transport, and landowner input on flow levels.

The group discussed the summary of landowner constraints listed below:

<u>BNSF Requirements</u>
☐Construction must not interfere with rail traffic
–Limits construction methods; eliminates open cut/culverts
☐Bridges cannot have piers that would rack LWD
☐Parallel structures must be constructed to accommodate potential future line expansion.
☐Must provide permanent access to each new structure.
☐Nostructures placed under or within 50' of BPA transmission lines.

<u>Landowners</u>
☐Must maintain flows in Nason Creek for creekside properties.
☐Maintain water rights.
☐Maintain existing groundwater.
☐Chelan County will not buy property to facilitate the project.

Upstream Oxbow
Detailed findings and cost estimates for each alternative are described in the powerpoint and are summarized in a table.

Preliminary Findings for the Upstream Site:

- BPA Transmission lines are located at the preferred downstream connection/outlet. This prevents the installation of any structures at that location so the outlet would need to be located upstream where the oxbow meanders close to the rail line.
- Existing BNSF access road from Merritt to the upstream connection can be used, needs some improvement.
- Risk of current main channel migrating at the upstream connection results in the need to move smaller structures (for 60% - 20% high flow) downstream a bit.

There was debate regarding the premise for selecting the alternatives based on a high flow and low flow goal. Some wondered how middle flow splits would work – like 60% or 40%. More discussion needs to occur on how to design the structures. Sediment transport analysis is needed for any flow alternative.

A question was brought up regarding the costs specifically tied to the construction of a second bridge at each connection for a future track. Some feel that funders may not want to fund this since it has no fish benefit and wondered if other funding sources (federal transportation dollars, BNSF, other) would be more appropriate and pursued.

There was discussion of the smaller tributaries that enter the oxbow (Gill Creek). There's a need to identify their location for both oxbows and get some flow data for them, especially late summer.

Downstream Oxbow
Again, the detailed findings and cost estimates for each alternative are described n the powerpoint.

Preliminary Findings for the Downstream Site:

- No existing access roads – permanent access roads would need to be built and would result in impacts to wetlands.
- Downstream outlet is proposed to the east of the existing culverts to 1) provide better equipment access; and 2) better align the outlet flows with the mainstem of Nason Creek. The existing culverts may remain without impact to the project success.
- Risk of channel migration at upstream end results in moving 60%-20% upstream inlets downstream of historic connection.

There was discussion of the access road construction and where fill material could come from. It was suggested that perhaps the full road would not be needed. Could we use a landing site to work off of?

New Alternative – Connect two oxbows with a constructed channel
A new alternative was presented that would connect the two oxbows with a 2,000 foot excavated channel. This would eliminate the need for two connections under the railroad and substantially reduce the amount of fill associated with the railroads requirement for an access road. The inlet at the upstream oxbow and the outlet at the downstream oxbow would be used.

Steve asked is phasing construction over 2 years would be beneficial? Work in 2011 could consist of most of the bridge work on the railroad except for excavating under the bridge to open up the channel. Work in 2012 could consist of work in the oxbow and construction of the 2,000' channel then opening up under the bridges.

We need to look into access under the BPA lines during construction. There's concern about clearing under the lines and impacts to the oxbow habitat.

We need to look into issues associated with the Gill Creek alluvial fan for construction. This could be a glacial fan and not active, however there could be issues if it's active and there's a big event in the future.

There was discussion about what work would be done in the channel and beaver impacts. We'd need to decide if we want to keep the channel wide or narrow it down to blow out beaver dams. There was concern that with only 20% of high flow the beaver dams may never get blown out and the whole area would become a flooded wetland with no defined channel.

The 20% high flow was presented as the most likely alternative for constructability and cost. There was discussion on still considering a range of flow options under this alternative. There is a limit on bridge size without having to construct a shoo fly track during construction and that's 15'-25'-15'. The flow limit depends on the shape of the channel and backwater effects. It is possible that more than 20% of the high flow could fit through this opening.

Suggested that we push the envelop on flow limits – get the highest flow for the structure.

Another Option: have multiple inlets or bigger connections for the connected oxbow alternative.

Question for BNSF – with the two middle connections gone, would a shoo fly need to span the entire project site to get bigger bridges or could there be two shorter shoo fly tracks, one at the inlet and one at the outlet?

Four Issues were summarized for bigger flows requiring the big bridges:

1. High cost
2. Landowner issues on the current channel – losing most flow
3. Will BNSF allow the large spanning bridges
4. There will be fill with the shoo fly needed

There was a discussion of what the limiting factors are that this project is trying to address. Full restoration of processes are not possible, so what biological benefit do we want? Channel Complexity, Diversity, Habitat Quantity and Floodplain Connectivity.

A question for the RTT is what information do they want to see for biological benefit?

Casey suggested not narrowing down the flow alternatives yet. There could be other funding out there to pay for the parts of the project that do not provide fish benefit.

The Design Team agreed to move forward with the Mega Oxbow Alternative (connecting the two oxbows) at a variety of flow alternatives. The other options are tabled for now in case we decide to look into any of them in more detail in the future.

- We need to find out the maximum capacity of the 25' span bridge.
- Consider bigger bridges – need to find out BNSF shoo fly needs, explore non-fish funding sources

The next Design Team meeting will be on Wednesday, May 19 in the afternoon after the Wenatchee Habitat Subcommittee Meeting at the Leavenworth Fire Hall.

Next Steps/Data Needs

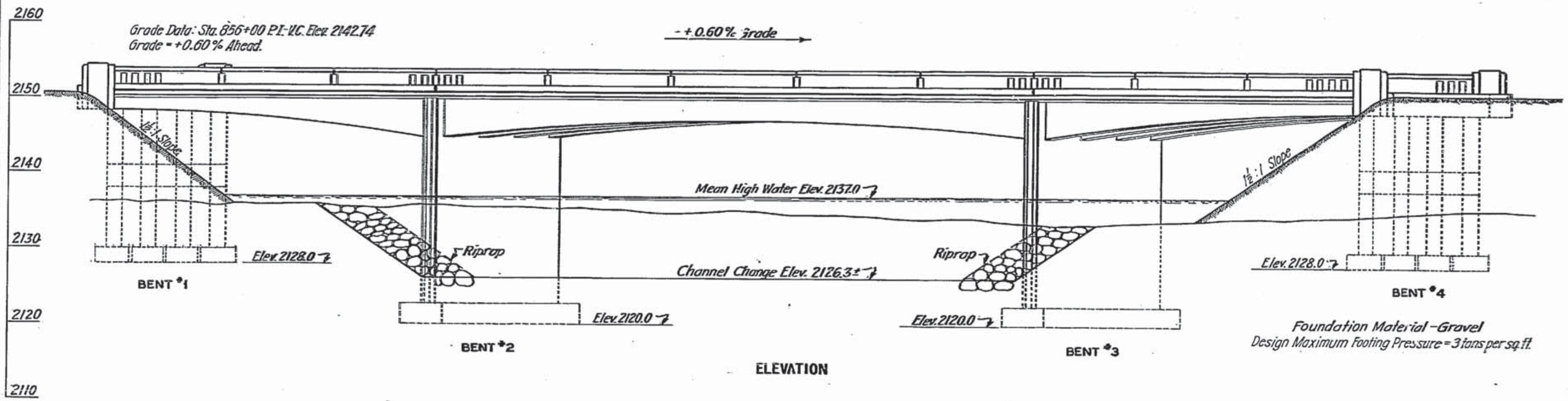
The new alternative, the Mega Oxbow, was presented to the UCRTT on April 14th and was well received. The RTT requested quantification of the amount of off-channel habitat that will be provided during high flows and low flows with this alternative. Reclamation will model the proposed inundation area for high and low-flow refugia.

- Model proposed inundation area – BOR (Sixta, Knutson, Soden)
- Sediment Transport Analysis – BOR (Sixta, Knutson, Soden)
- Collect bed material for sediment transport – BOR
- Wetland Delineation – BOR
- Cultural Resources – BOR
- Geotechnical Survey – BOR
- Topographic Survey – BOR
- Temperature in Oxbow – temp in upper and lower oxbows; stratified

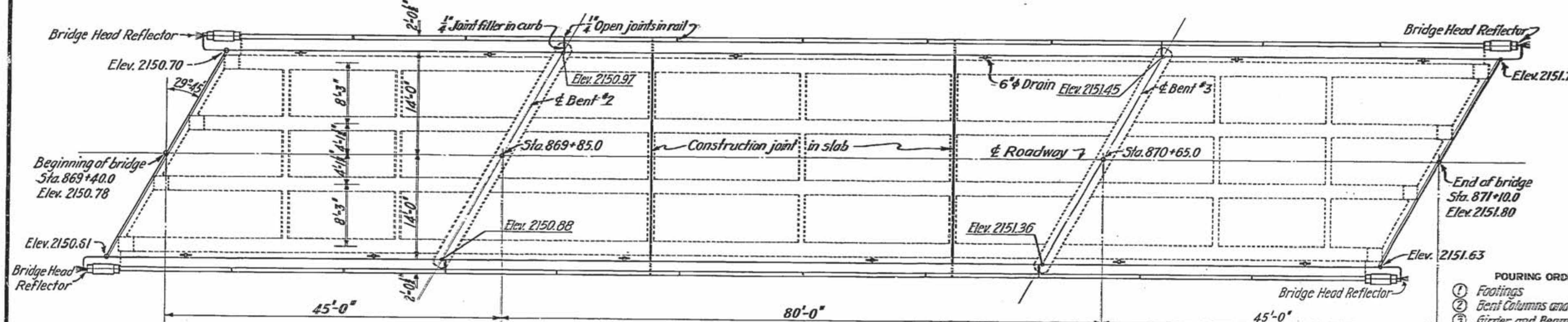
- Groundwater – install during geotech drilling
- Hydrology – gages on mainstem Nason, Gill Cr., Roaring Cr., and Coulter Cr.
- Water Surface Elevation – survey at higher flow nr bridges and wetland
- Survey profile? – may not be needed with BOR topo
- Fish data?
- Historical data from forest service

Appendix C

WSDOT Bridge #2 207 Details



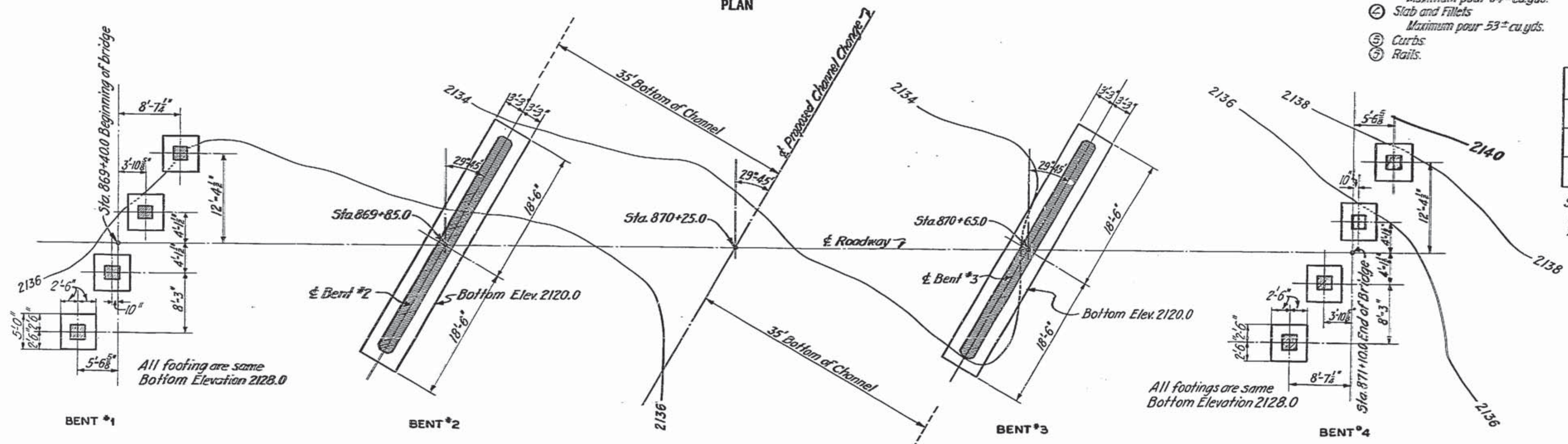
ELEVATION



PLAN

POURING ORDER

1. Footings
2. Bent Columns and Walls
3. Girder and Beam Stems
   Maximum pour 64± cu. yds.
4. Slab and Fillets
   Maximum pour 53± cu. yds.
5. Curbs
6. Rails.



FOOTING PLAN

GENERAL NOTES

SPECIFICATIONS: Construction, Public Roads Administration Specification FP41. Design, AASHO Standard Specifications for Highway Bridges 1949.

DEAD LOAD: Concrete 150# per cu. ft. Paving allowance 25# per sq. ft. of roadway surface.

LIVE LOAD: H20-S16-44. Impact $I = \frac{50}{L+125}$ (L = span length) Maximum I = 30%.

UNIT STRESSES: $f_c = 1200$ p.s.i. $f_s = 20,000$ p.s.i. $n = 10$.

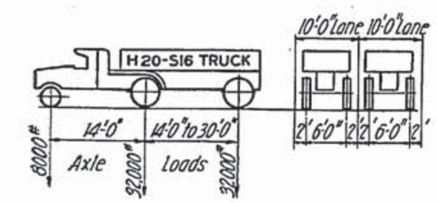
CONCRETE: All concrete shall be Class "A" except in railing, which shall be Class "Y." Maximum size of coarse aggregate 1½" for Class "A" and ¾" for Class "Y." All concrete shall be mixed with Type II Portland Cement (low alkali) and with an air entraining agent. All concrete shall be vibrated. All exposed corners shall be chamfered ¾" unless otherwise shown.

FINISHING CONCRETE: Roadway slab and curbs shall be finished according to specifications. The following surfaces shall be given a "Rubbed Finish": All faces of rail and rail posts, outside faces of slab and curbs and outside faces of exterior girders. All other exposed faces shall be given an "Ordinary Finish."

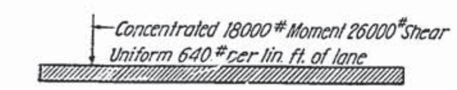
REINFORCING STEEL: All bars shall be deformed intermediate grade steel conforming to A.S.T.M. Specifications A15-39 and A305-49. Equivalent round bars may be substituted for square bars shown. All bars in slab shall be supported on "metal chairs." Except as shown all dimensions refer to centers of bars.

RAILING: All items of rail construction above top of curb are included in the contract item for "Railing" and include the Class "Y" concrete and reinforcing bars.

BRIDGE HEAD REFLECTORS: Four reflectors will be furnished by the Bureau of Public Roads. Cost of installation shall be included in the contract price for "Railing."



H20-S16-44 TRUCK DIAGRAM



H20-S16-44 LANE LOADING

ESTIMATE

	SUBSTRUCTURE	SUPERSTRUCTURE
Structure Excavation	360 cu. yds.	
Class A Concrete	199 cu. yds.	339 cu. yds.
Reinforcing Steel	16,000 lbs.	68,000 #
Railing		350 lin. ft.

Structure Excavation measured below channel change. Weight of drains included in weight of superstructure reinforcing steel.

DESIGNED BY N.B. March 1952
DRAWN BY N.B. " March "
TRACED BY G.A.R. March 1952
CHECKED BY G.R.B. April & Nov. 1952

APPROVED H.R. Angwin SUPERVISING HIGHWAY BRIDGE ENGINEER

REVISED DEC. 5, 1952

DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS WESTERN HEADQUARTERS

NASON CREEK BRIDGE

STEVENS PASS HIGHWAY
WASHINGTON FOREST HIGHWAY PROJECT 8-A6,G

SCALE: ⅛" = 1'-0" APRIL 1952

SHEET 1 OF 4 SHEETS RG 1099-A
138/0

Appendix D

Alternatives Matrix

Table D-1. Alternatives Matrix

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
100% Connection - 4 220-foot span bridges	**Low:** Must move BPA lines; significant oxbow and channel work; access road construction will be required.	**High:** Main Channel will be lengthened and floodplain and off-channel habitats will be reconnected. Full channel processes will be restored. Gill Creek basin will be reconnected.	**High:** Mainstem and oxbow habitats will be impacted through excavation and stabilization measures; access roads will fill wetland areas along tracks; spawning habitat along mainchannel will be removed for 0.4 mil	**Low:** Will remove "river-front" property. Will require moving BPA lines.	**High:** $21+ Million	Feasibility of this alternative is very low due to the need and unknown cost associated with moving the BPA transmission line. Also, a large cost associated with this alternative is associated with the parallel bridge construction and access road construction. Impacts to existing habitats due to creek stabilization and fill, and excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
80% Flow (80% high flow; 20% min. low flow) - 4 220-foot span bridges	**Low:** Must move BPA lines; significant oxbow and channel work; access road construction will be required.	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Gill Creek basin will be reconnected.	**High:** Mainstem and oxbow habitats will be impacted through excavation and stabilization measures; access roads will fill wetland areas along tracks; spawning habitat	**Low**: Will remove "river-front" property. Will require moving BPA lines.	**High:** $21+ Million	Feasibility of this alternative is very low due to the need and unknown cost associated with moving the BPA transmission line. Also, a large cost associated with this alternative is associated with the parallel bridge construction and access

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
			along mainchannel will be removed for 0.4 mil			road construction. Impacts to existing habitats due to creek stabilization and fill, and excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
60% Flow (60% high flow; 20% min. low flow) - 4 160-foot span bridges	**Low:** Must either move BPA lines or connect upstream; oxbow and mainstem work will be needed to stabilize the openings and increase oxbow capacity; access road improvements will be required.	**Moderate**: Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Gill Creek basin will be reconnected.	**Moderate:** Oxbow habitats will be impacted through excavation to increase capacity, improved access roads will fill wetland areas; change to mainstem sediment transport likely to increase fines and could impact spawning habitats.	**Moderate:** Will maintain some flow in the mainchannel for private landowner use. May require moving BPA transmission lines.	**High:** $18+ Million	Feasibility of this alternative is very low due to the need and unknown cost associated with moving the BPA transmission line. If this option is not chosen then the total linear feet of reconnection would be less than 1,000 of oxbow. Also, a large cost associated with this alternative is associated with the parallel bridge construction. Impacts to existing habitats due to excavation to increase oxbow capacity may exceed project benefits especially if moving the BPA lines is not implemented.

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
						Recommendation: Remove from consideration.
40% Flow(40% high flow; 20% min. low flow) - 4 160-foot span bridges	**Low:** Must either move BPA lines or connect upstream; oxbow and mainstem work will be needed to stabilize the openings and increase oxbow capacity; access road improvements will be required.	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Gill Creek basin will be reconnected.	**Moderate:** Oxbow habitats will be impacted through excavation to increase capacity, improved access roads will fill wetland areas; change to mainstem sediment transport likely to increase fines and could impact spawning habitats.	**Moderate:** Will maintain some flow in the mainchannel for private landowner use. May require moving BPA transmission lines.	**High:** $18+ Million	**Feasibility of this alternative is the same as the 60% connection**: very low due to the need and unknown cost associated with moving the BPA transmission line. If this option is not chosen then the total linear feet of reconnection would be less than 1,000 of oxbow. Also, a large cost associated with this alternative is associated with the parallel bridge construction. Impacts to existing habitats due to excavation to increase oxbow capacity may exceed project benefits especially if moving the BPA lines is not implemented. **Recommendation: Remove from consideration.**
20% Flow(20%	**Moderate:** Must either move BPA	**Moderate:** Floodplain will be reconnected. High flow	**Low:** Minor impacts to oxbow	**Moderate:** Will maintain flows in the	**Moderate:** $4+	Feasibility of this alternative is moderate

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
high flow; 20% min. low flow) - 4 55-foot span bridges	lines or connect upstream; Minor excavation in the oxbow will be needed at both upstream and downstream connection points.; access road improvements will be required.	refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Gill Creek basin will be reconnected.	habitats through excavation at connections, improved access roads will fill wetland areas; No change in mainstem sediment transport.	mainchannel for private landowner use. May require moving BPA transmission lines.	Million	if moving the BPA transmission line is not chosen. If this option is not chosen then the total linear feet of reconnection would be less than 1,000 of oxbow but fish would be able to enter and utilize the oxbow as off-channel habitat year-round. This alternative also maintains existing habitats and characteristics on the mainstem. **Recommendation: Remove from consideration.**
Groundwater-Charged channel (outlet only) - 2 55-foot span bridge	**Moderate:** Single connection feasible upstream of BPA lines; Minor excavation in the oxbow will be needed at the connection point.; access road improvements will be required.	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Gill Creek basin will be reconnected. Lack of flow-through habitat may not directly benefit listed salmonids.	**Low:** Minor impacts to oxbow habitats through excavation at the single connection, improved access road will fill wetland areas; No change in mainstem sediment transport.	**High:** Will maintain flows in the mainchannel for private landowner use. No need to move BPA lines.	**Moderate:** $2+ Million	Feasibility of this alternative is moderate as a single connection point midway down the oxbow is located directly adjacent to the railroad prism and upstream of the BPA lines. Would only require the construction of 2 bridge structures. Fish would be able to enter and utilize the oxbow as off-channel habitat year-round. This alternative also maintains existing

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
						habitats and uses on the mainstem. Reconnects the Gill Creek basin. **Recommendation: Continue to evaluate.**
100% Connection - 4 220-foot span bridges	**Low:** Significant oxbow and channel work; access road construction will be required. The inlet location will require at least a 2,500 l.f. access road through wetland areas.	**High:** Main Channel will be lengthened and floodplain and off-channel habitats will be reconnected. Full channel processes will be restored. Coulter and Roaring Creek basin will be reconnected.	**High:** Mainstem and oxbow habitats will be impacted through excavation and stabilization measures; access roads will fill wetland areas along tracks; spawning habitat along mainchannel will be removed for 0.4 mil	**Low:** Will remove "river-front" property.	**High:** $21+ Million	Feasibility of this alternative is very low due to the need to fill the existing creek channel and excavate the oxbow. Also, a large cost associated with this alternative is associated with the parallel bridge construction and access road construction. Impacts to existing habitats due to creek stabilization and fill, and excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
80% Flow (80% high flow; 20% min. low flow) - 4 220-foot span bridges	**Low:** Significant oxbow and channel work; access road construction will be required. The inlet location will	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Coulter and Roaring Creek basin will be	**High:** Mainstem and oxbow habitats will be impacted through excavation and stabilization measures; access roads will fill	**Low**: Will remove "river-front" property.	**High:** $21+ Million	Feasibility of this alternative is very low due to the need to fill the existing creek channel and excavate the oxbow. Also, a large cost associated with this alternative is

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
	require at least a 2,500 l.f. access road through wetland areas.	reconnected.	wetland areas along tracks; spawning habitat along mainchannel will be removed for 0.4 mil			associated with the parallel bridge construction and access road construction. Impacts to existing habitats due to creek stabilization and fill, and excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
60% Flow (60% high flow; 20% min. low flow) - 4 160-foot span bridges	**Low:** Oxbow and mainstem work will be needed to stabilize the openings and increase oxbow capacity; The inlet location will require at least a 2,500 l.f. access road through wetland areas.	**Moderate**: Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Coulter and Roaring Creek basin will be reconnected.	**Moderate:** Oxbow habitats will be impacted through excavation to increase capacity, improved access roads will fill wetland areas; change to mainstem sediment transport likely to increase fines and could impact spawning habitats.	**Moderate:** Will maintain some flow in the mainchannel for private landowner use.	**High:** $18+ Million	Feasibility of this alternative is low due to the high cost and construction access difficulty at the inlet location. A large cost associated with this alternative is associated with the parallel bridge construction. Impacts to existing habitats due to excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
40% Flow(40% high flow;	**Low:** Oxbow and mainstem work will be	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow	**Moderate:** Oxbow habitats will be impacted through	**Moderate:** Will maintain some flow in the mainchannel	**High:** $18+ Million	**Feasibility of this alternative is the same as the 60%**

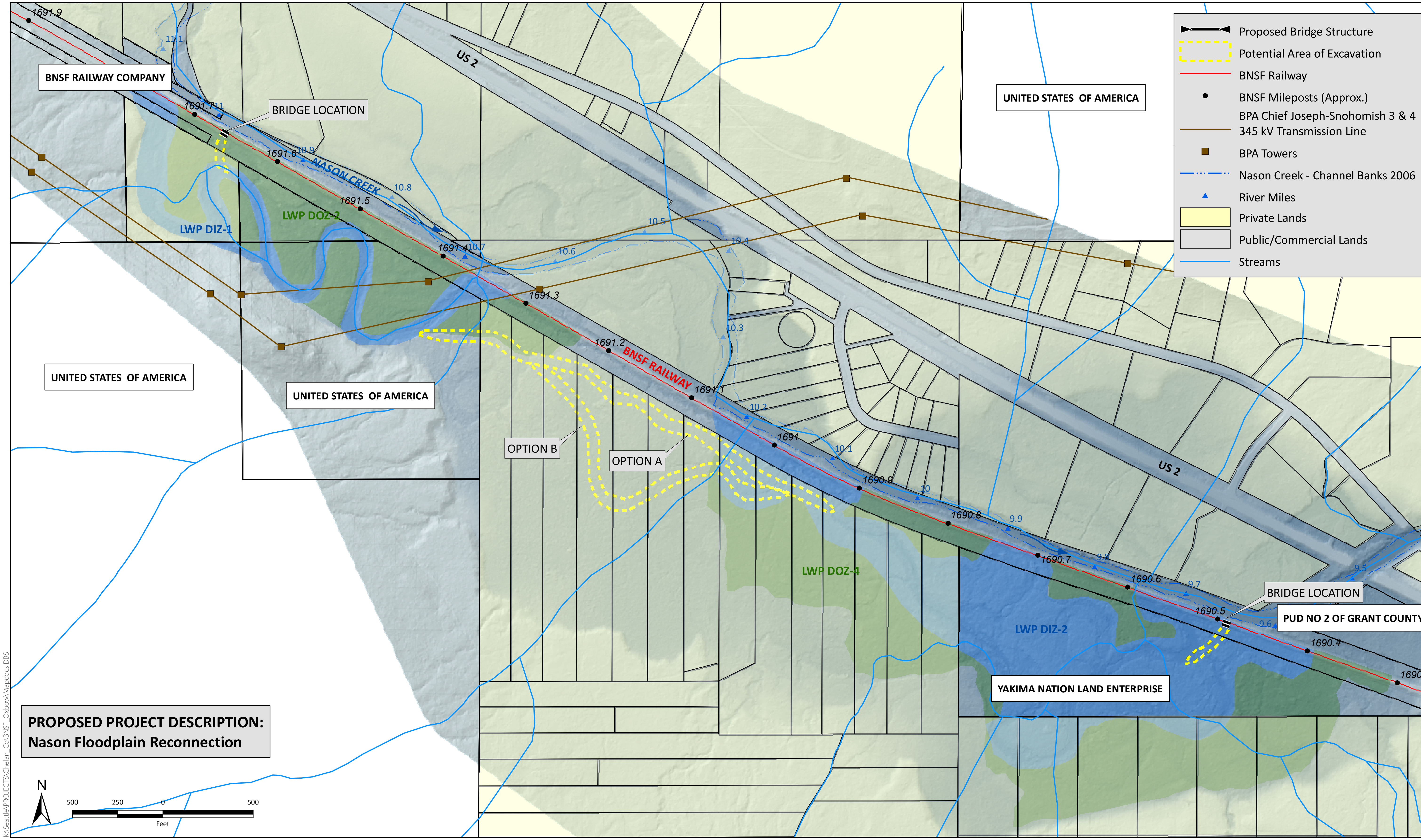
Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
20% min. low flow) - 4 160-foot span bridges	needed to stabilize the openings and increase oxbow capacity; The inlet location will require at least a 2,500 l.f. access road through wetland areas.	through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Coulter and Roaring Creek basin will be reconnected.	excavation to increase capacity, improved access roads will fill wetland areas; change to mainstem sediment transport likely to increase fines and could impact spawning habitats.	for private landowner use.		**connection**: low due to the high cost and construction access difficulty at the inlet location. A large cost associated with this alternative is associated with the parallel bridge construction. Impacts to existing habitats due to excavation to increase oxbow capacity may exceed project benefits. **Recommendation: Remove from consideration.**
20% Flow(20% high flow; 20% min. low flow) - 4 55-foot span bridges	**Moderate:** Minor excavation in the oxbow will be needed at both upstream and downstream connection points. The inlet location will require at least a 2,500 l.f. access road through wetland areas.	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Coulter and Roaring Creek basin will be reconnected.	**Low:** Minor impacts to oxbow habitats through excavation at connections, improved access roads will fill wetland areas; No change in mainstem sediment transport.	**Moderate:** Will maintain flows in the mainchannel for private landowner use. Will improve drainage behind BNSF rail prism.	**Moderate:** $4+ Million	Feasibility of this alternative is moderate, however will require extensive access road construction for the upstream inlet bridge structures. Impacts to existing habitats will be low, and fish would be able to enter and utilize the oxbow as off-channel habitat year-round. This alternative also maintains existing stream characteristics on the mainstem. **Recommendation: Remove from consideration.**

Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
Groundwater-Charged channel (outlet only) - 2 55-foot span bridge	**Moderate:** Minor excavation in the oxbow will be needed at the connection point.; access road improvements will be required to reach the single downstream connection but would not exceed 1,000 l.f. in length.	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Coulter and Roaring Creek basin will be reconnected. Lack of flow-through habitat may not directly benefit listed salmonids.	**Low:** Minor impacts to oxbow habitats through excavation at the single connection, improved access road will fill wetland areas; No change in mainstem sediment transport.	**High:** Will maintain flows in the mainchannel for private landowner use. Will improve drainage behind BNSF rail prism.	**Moderate:** $2+ Million	Feasibility of this alternative is moderate as a single connection point at the downstream end of the oxbow is located directly adjacent to the railroad prism. Fish would be able to enter and utilize the oxbow as off-channel habitat year-round. This alternative also maintains existing habitats and characteristics on the mainstem. This alternative would reconnect Gill, Coulter, and Roaring Creek basins while providing valuable off-channel refuge. **Recommendation: Continue to evaluate.**
Connector Channel Alternative - 4 bridges (<55-foot span); 2,000 l.f. connection channel	**Moderate:** Connection points would utilize spans less than 55-feet in length requiring minor excavation in the oxbow at connection points. Access	**Moderate:** Floodplain will be reconnected. High flow refugia will be created. Flow through habitat will directly benefit listed salmonids. Partial channel processes will be restored. Gill, Coulter and Roaring Creek basins will be reconnected.	**Moderate:** Minor impacts to oxbow habitats through excavation at the single connection, improved access road will fill wetland areas; No change in mainstem sediment	**High:** Will maintain flows in the mainchannel for private landowner use.	**Moderate:** $9 Million	Feasibility of this alternative is moderate, however will require extensive excavation of the connection channel. The alternative would remove the need for 8 bridge structures and the majority of the access road construction. Would

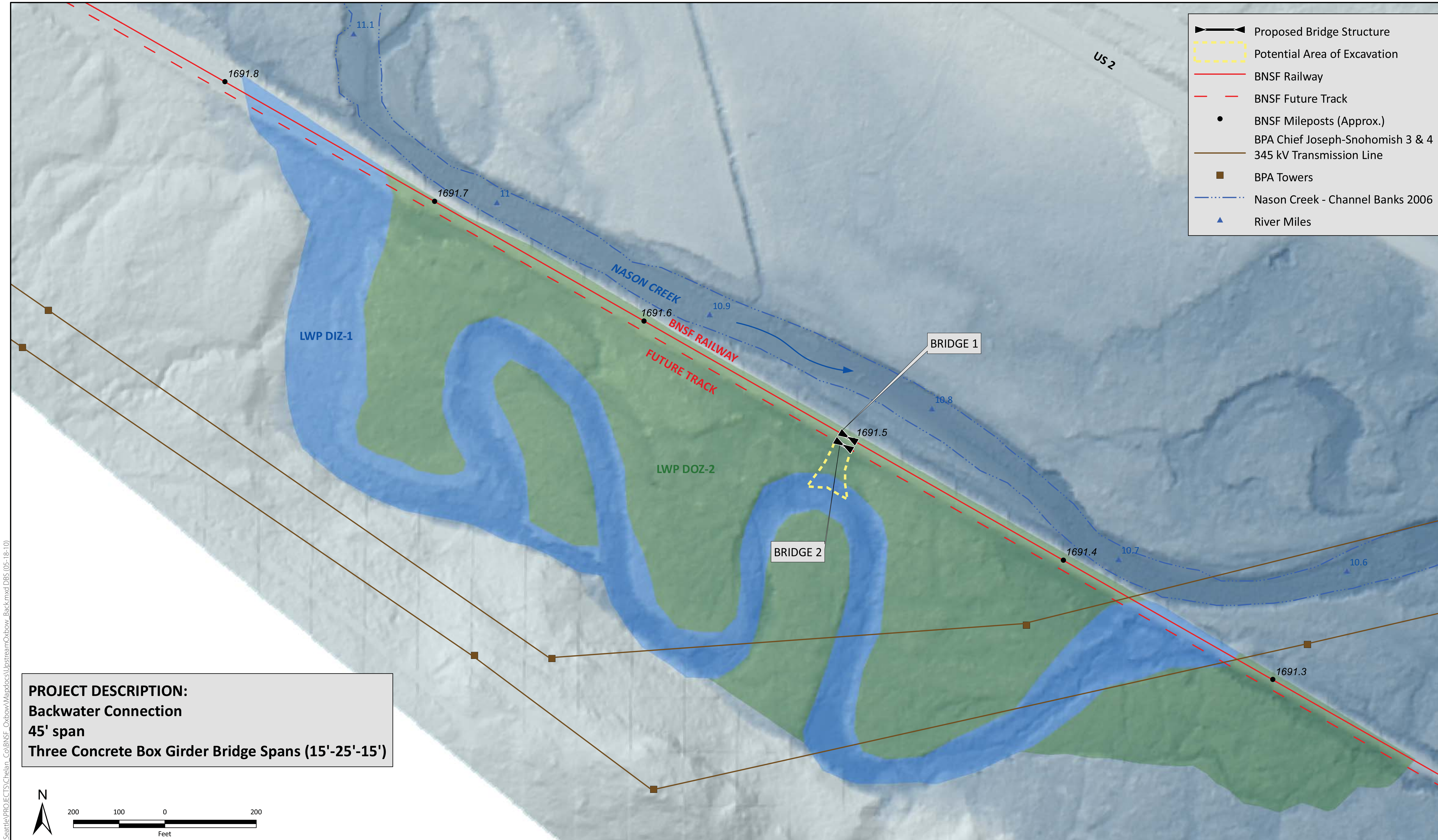
Alternative	Construction Feasibility	Ability to Address Biological Limiting Factors	Potential Impacts	Landowner Acceptance	Cost	Summary
	road construction will be required but will be restricted to upstream and downstream connection points. Channel excavation could be difficult in wet conditions. No interferrence with BPA lines.		transport. Channel connection will require excavation in wetland area and removal of riparian vegetation.			create large contiguous habitat for less than the cost of constructing both 20% Flow Alternative projects. Impacts to existing habitats will be moderate, but fish would be able to enter and utilize both of the oxbows as contiguous off-channel habitat year-round. This alternative also maintains existing stream characteristics on the mainstem. This alternative would reconnect Gill, Coulter, and Roaring Creek basins while providing valuable off-channel refuge. **Recommendation: Continue to evaluate.**

Appendix E

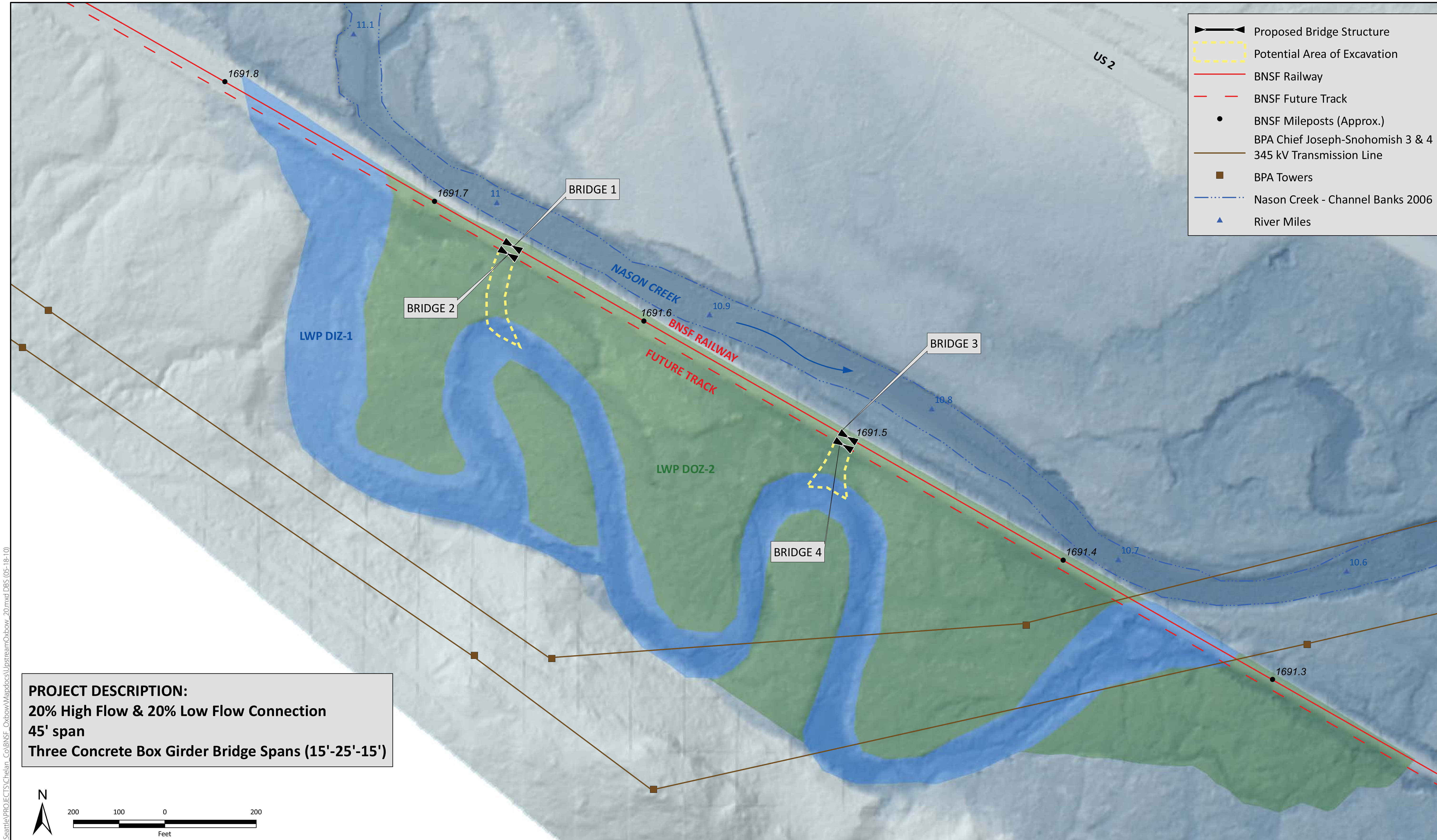
Alternative Concept Plans



Oxbow Connection (LWP DIZ-1, DIZ-2, DOZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives



Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



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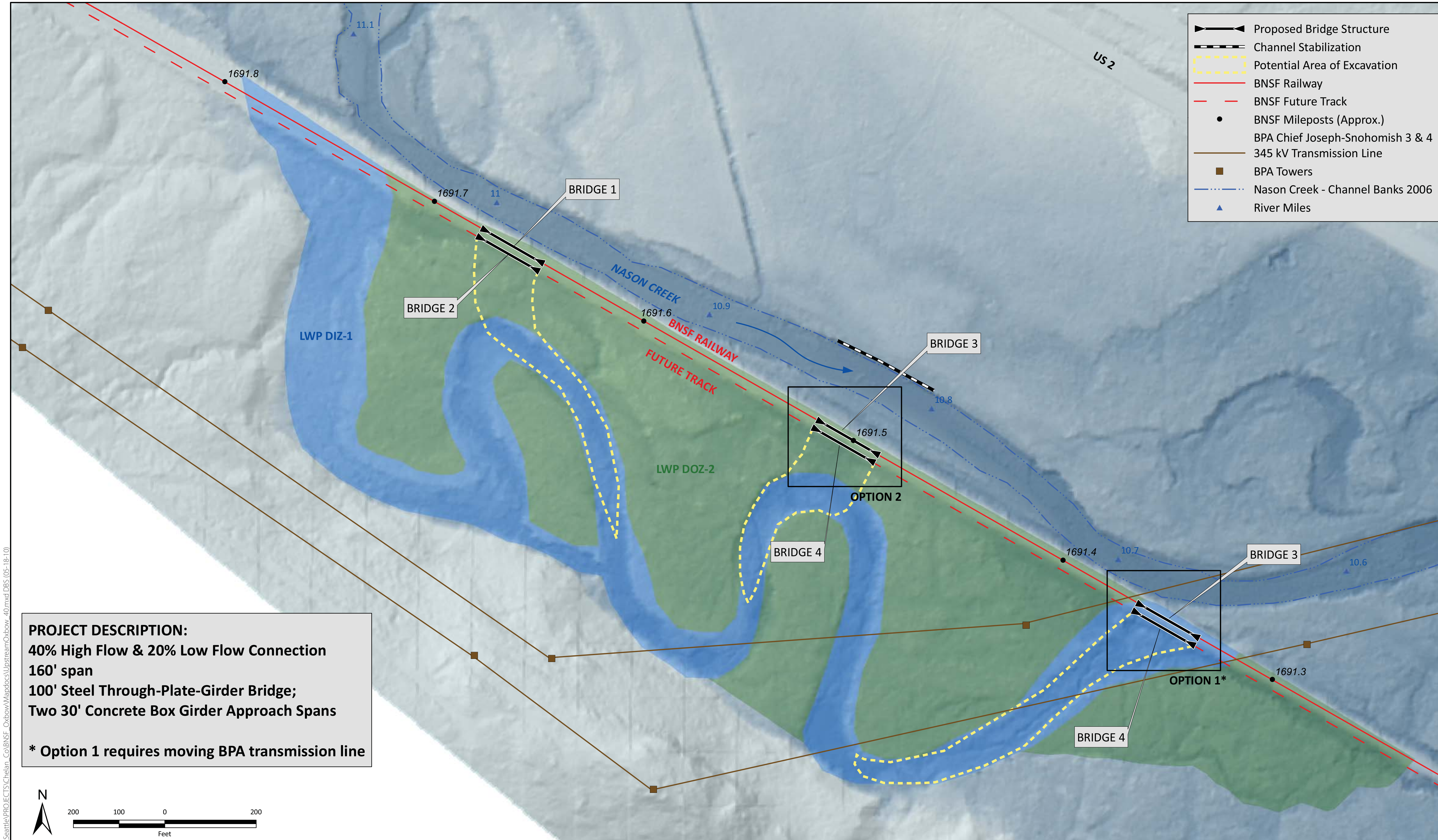
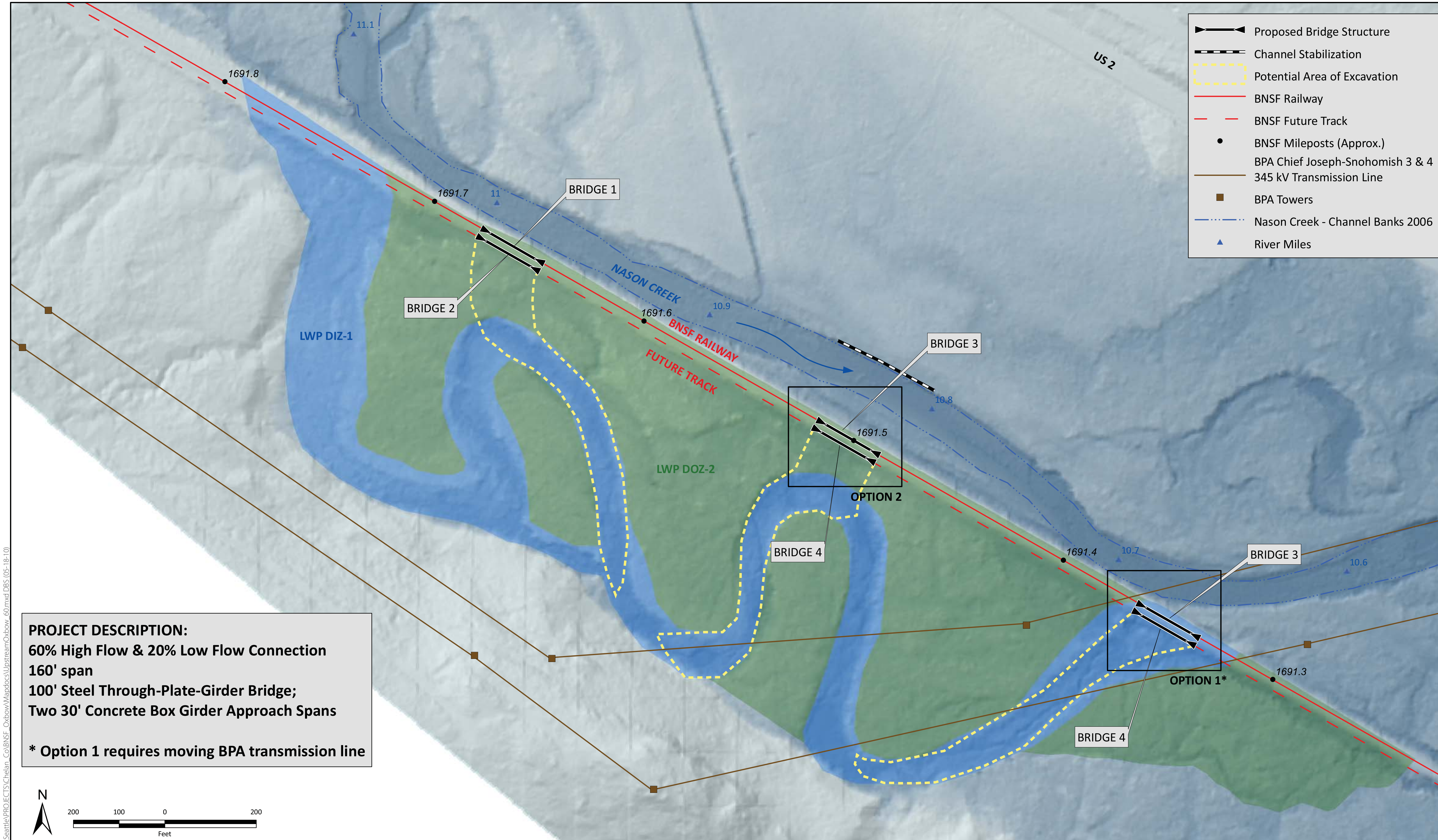
ICF INTERNATIONAL

Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



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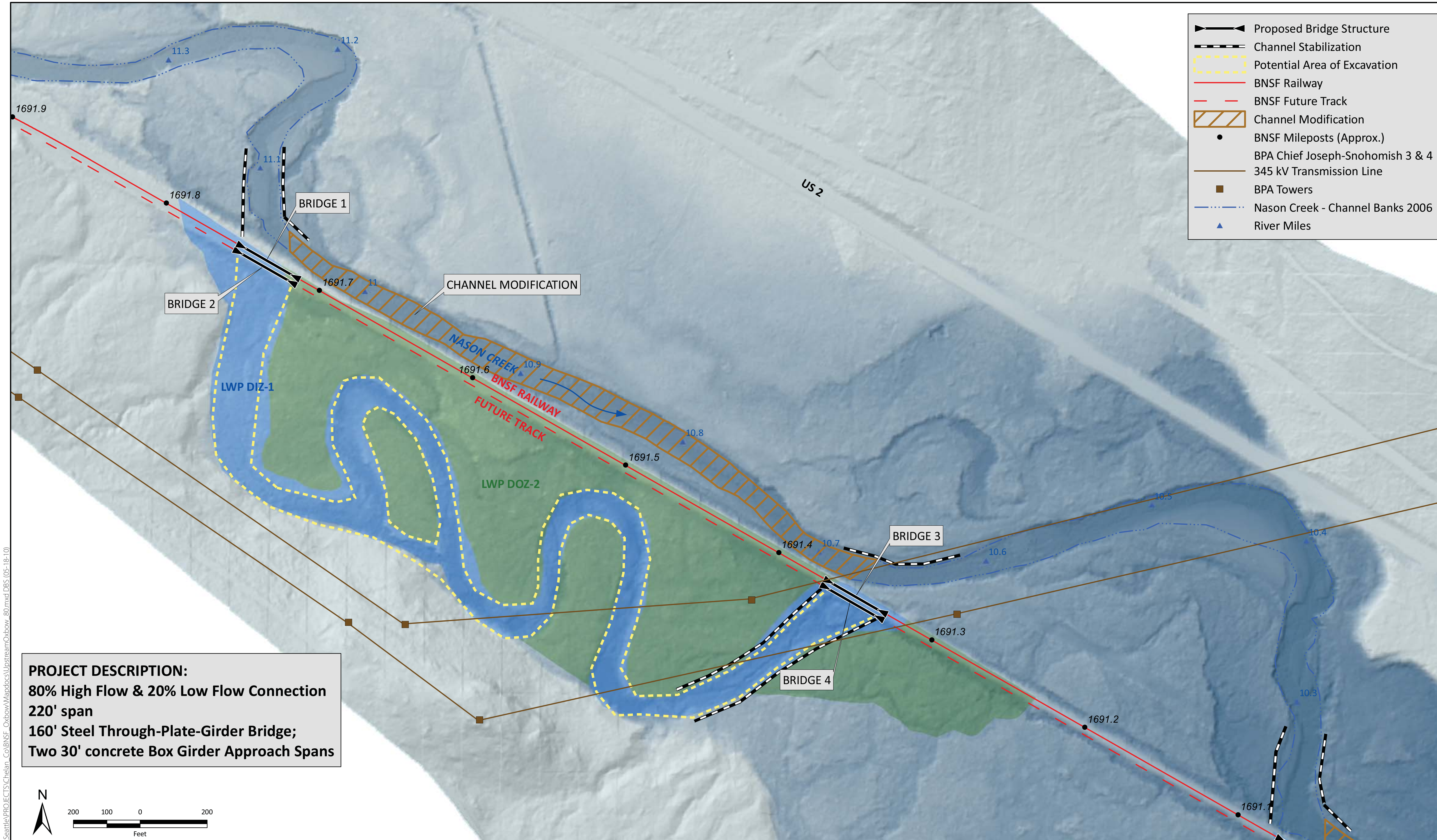
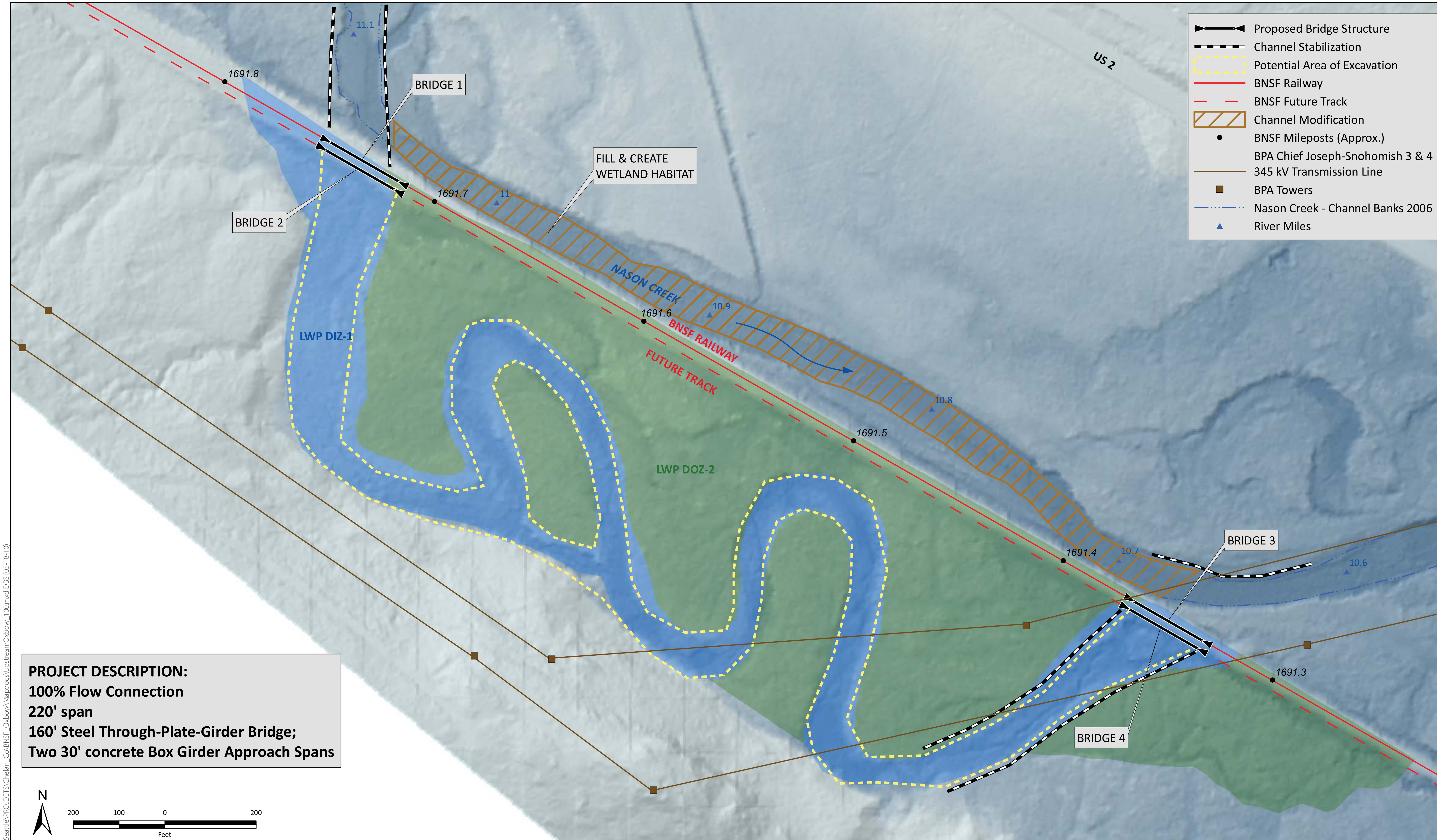
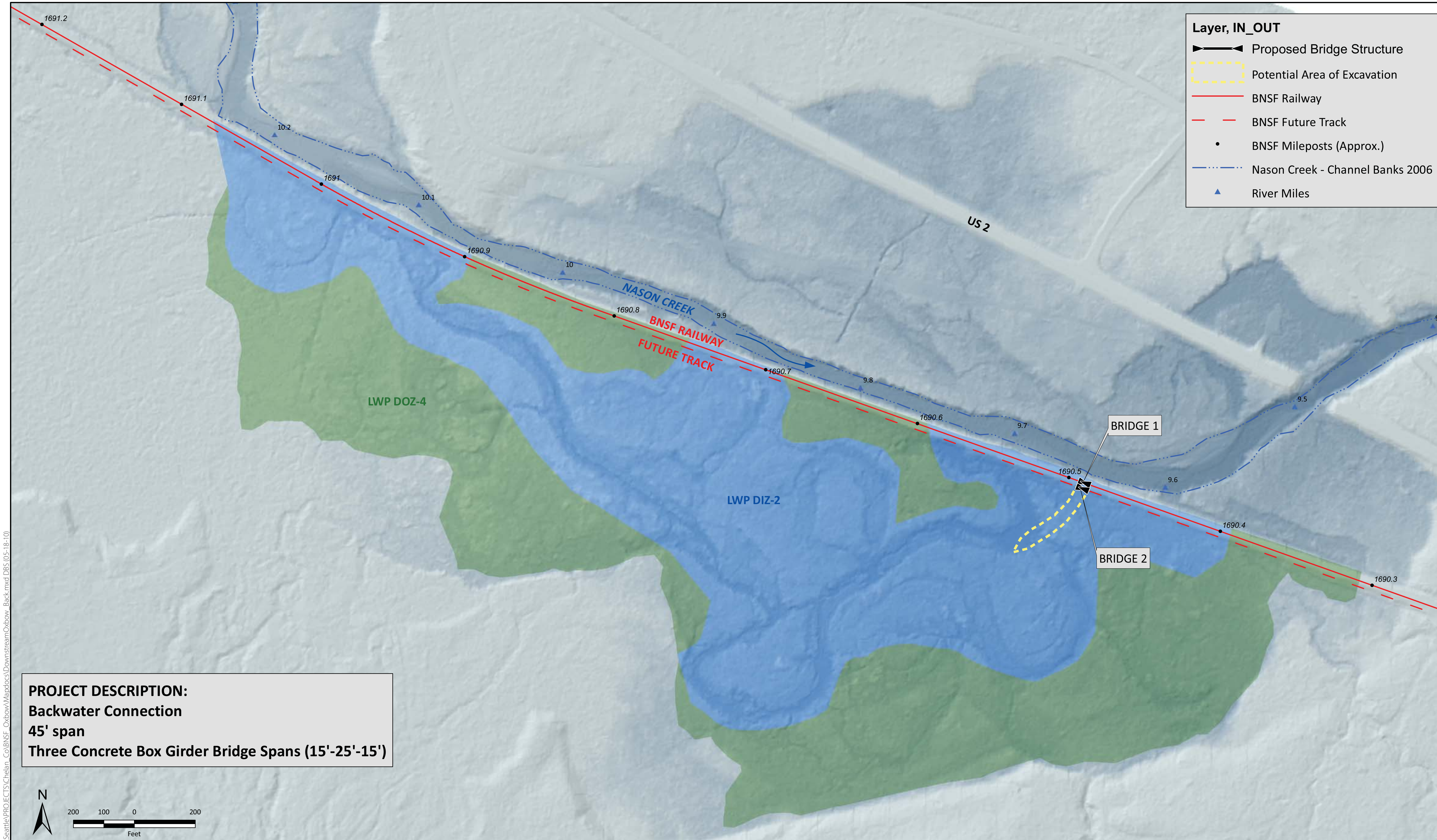
Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



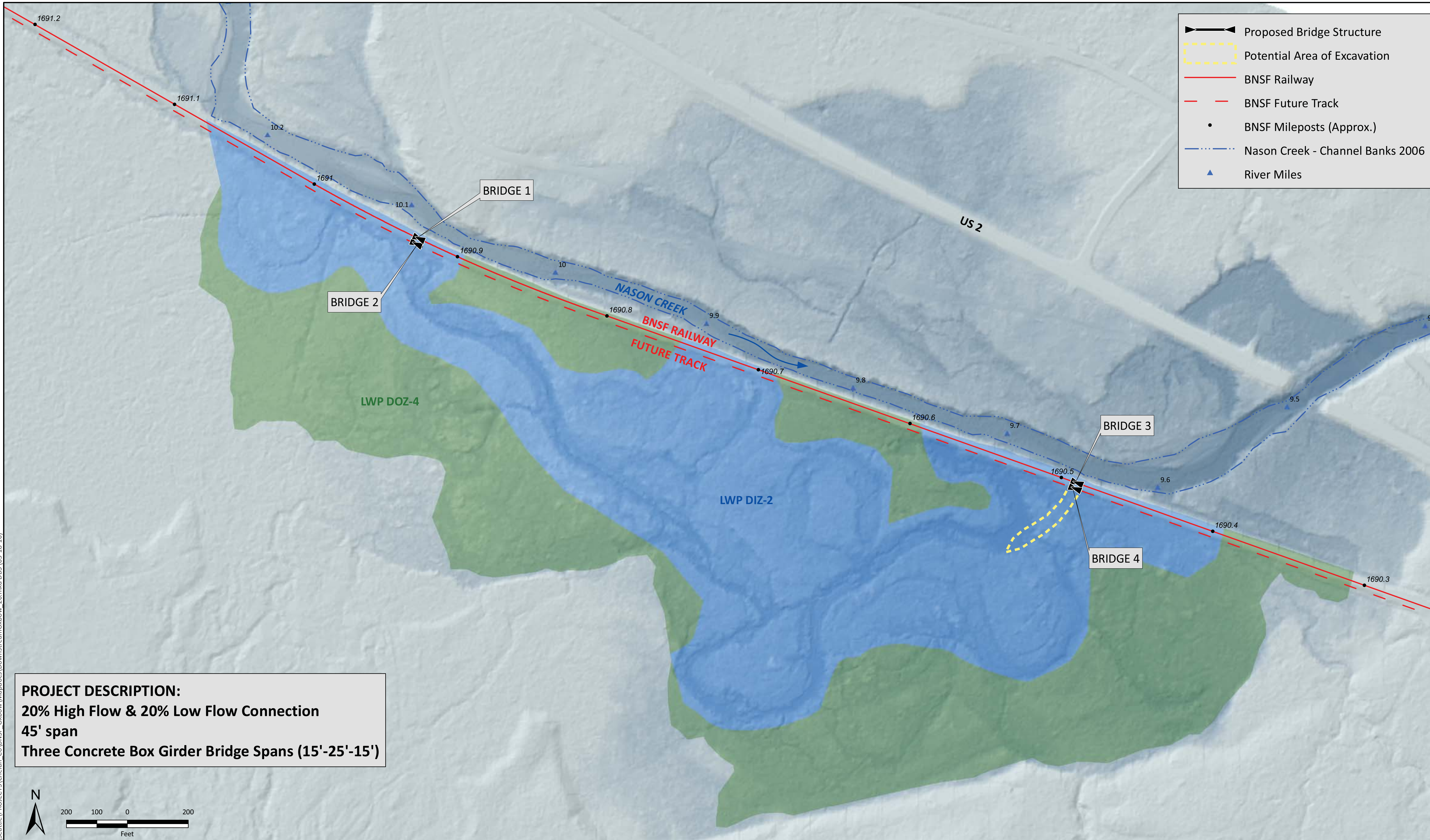
Upstream Oxbow (LWP DIZ-1 & DOZ-2)
BNSF Railway - Nason Creek Alternatives



PROJECT DESCRIPTION:
Backwater Connection
45' span
Three Concrete Box Girder Bridge Spans (15'-25'-15')

ICF INTERNATIONAL

Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives



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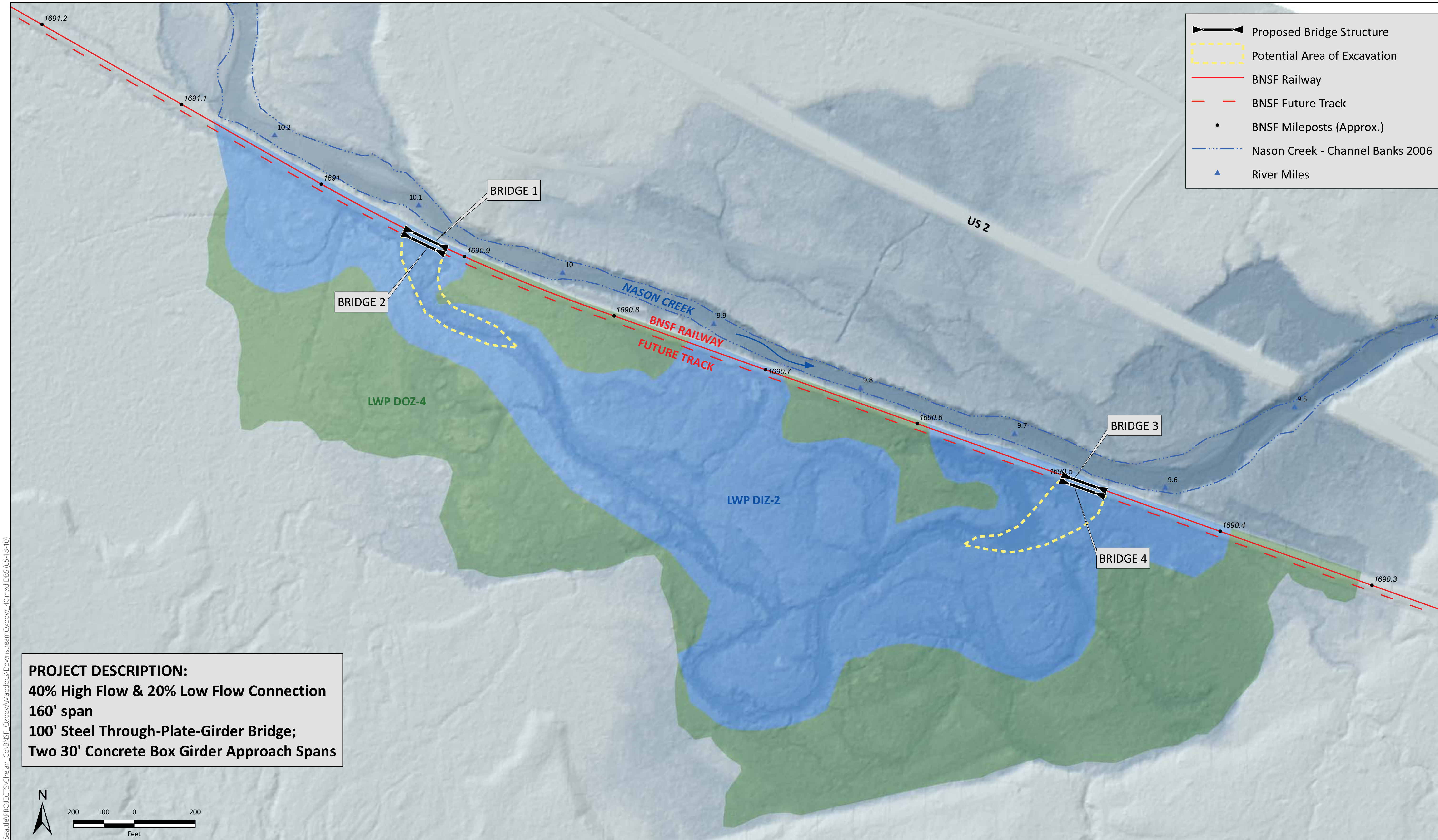
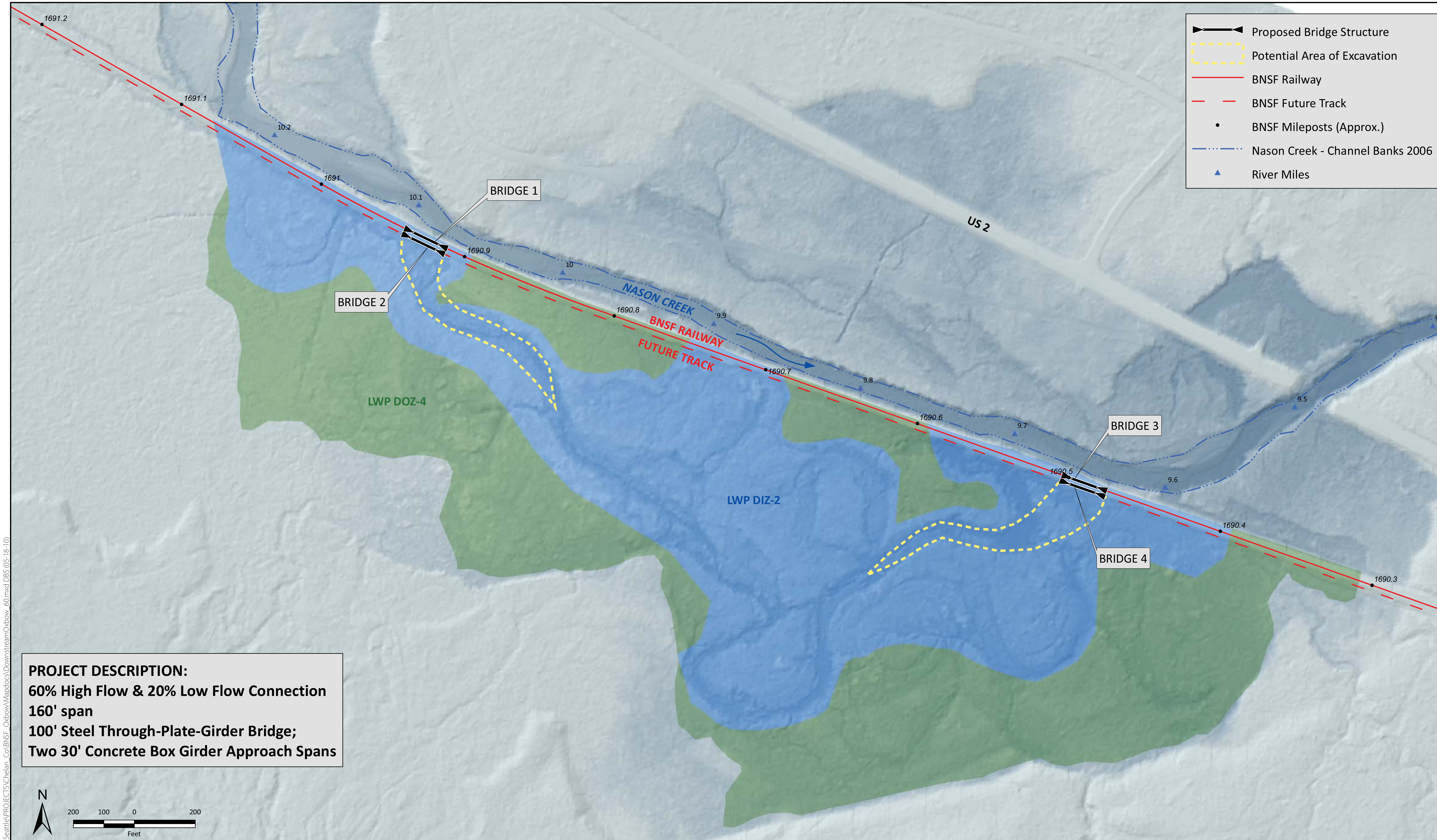
ICF INTERNATIONAL

Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives

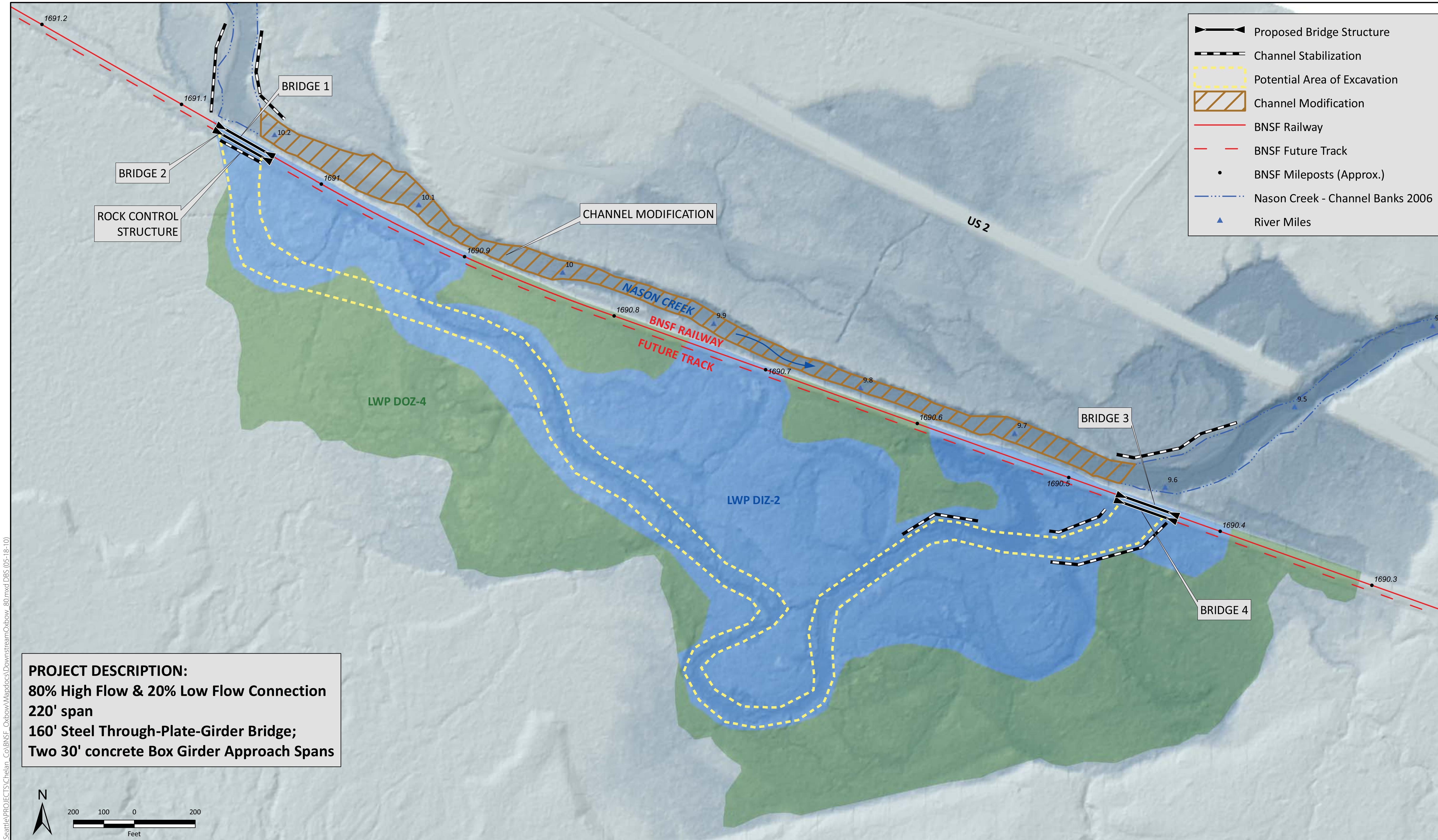


Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives

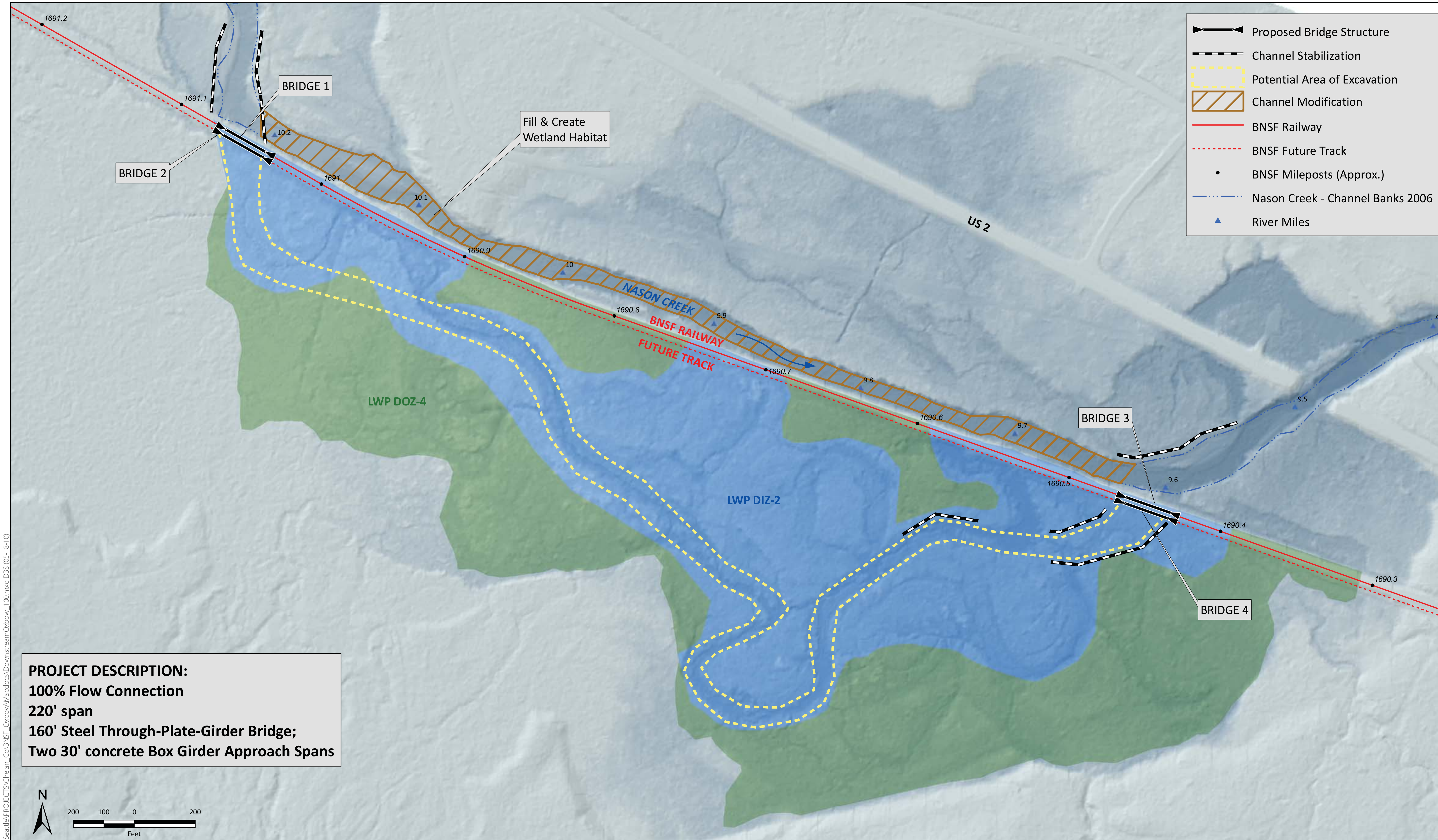


ICF INTERNATIONAL

Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives

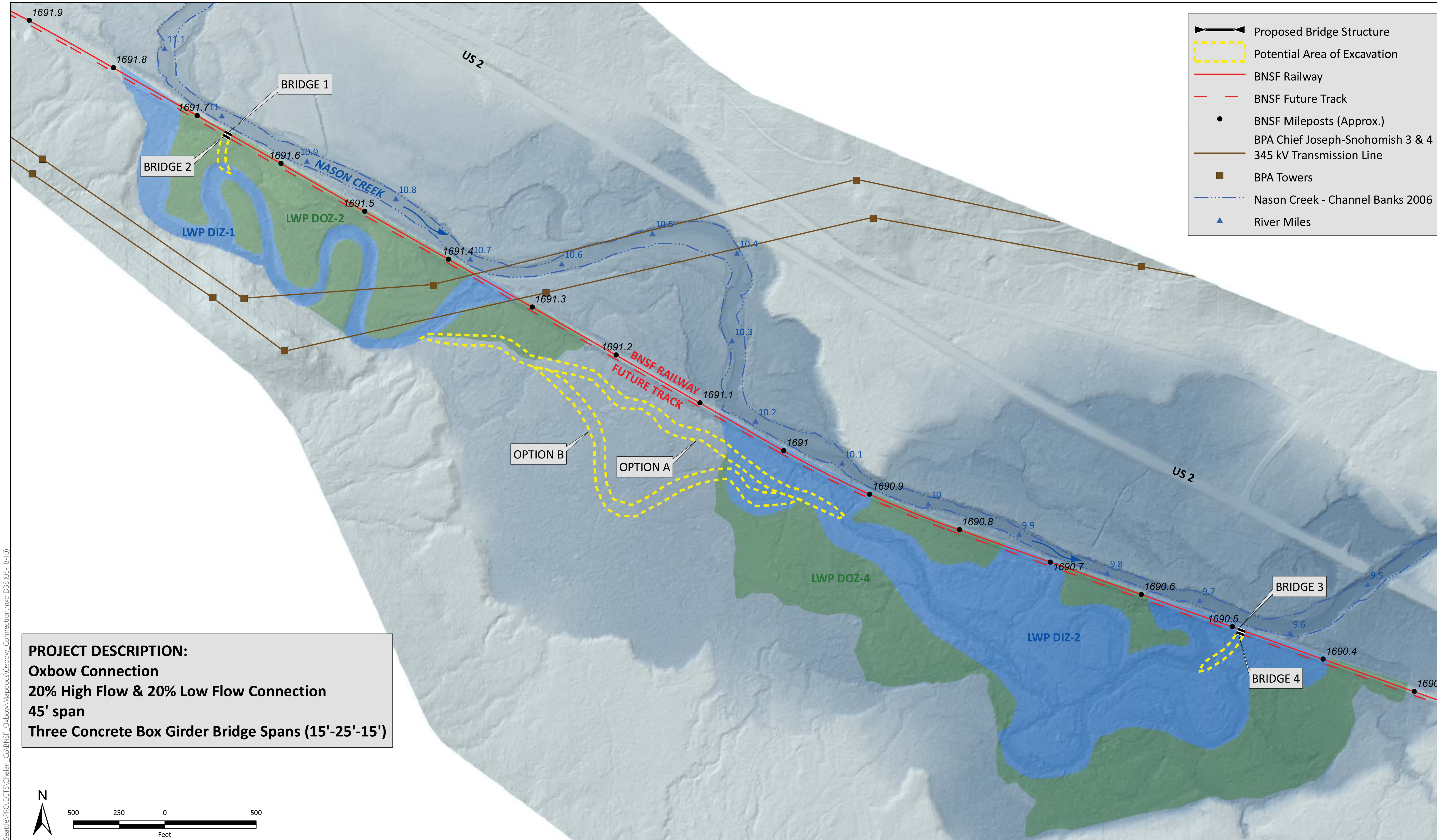


Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives



ICF INTERNATIONAL

Downstream Oxbow (LWP DIZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives



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Oxbow Connection (LWP DIZ-1, DIZ-2, DOZ-2 & DOZ-4)
BNSF Railway - Nason Creek Alternatives