Final Basis of Design Report

Lapwai Creek Reach 14
Floodplain and Habitat Restoration
Nez Perce County, Idaho

for
Nez Perce Tribe

September 29, 2021

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File No. 0571-022-00

September 29, 2021

Prepared for:

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GEOENGINEERS

Table of Contents

FIGURES

APPENDICES

LIST OF ACRONYMS

Bankfull Width – BFW

BPA – Bonneville Power Administration

cfs – cubic feet per second

ESA – Endangered Species Act

FOS – Factor of Safety

HIP – Habitat Improvement Program

IDT – Idaho Transportation Department

LWM – Large Woody Material

NMFS – National Marine Fisheries Service

NPT – Nez Perce Tribe

ODFW – Oregon Department of Fish and Wildlife

OWRD – Oregon Water Resources Department

RRT – Restoration Review Team

RSI – Resource Specialists, Inc.

USACE – United States Army Corps of Engineers

USGS – Unites States Geological Society

1.0 INTRODUCTION

GeoEngineers, Inc. (GeoEngineers) has prepared this Final Basis of Design report (report) for the Nez Perce Tribe (NPT). This report provides a summary of our findings pertaining to the existing conditions of the Lapwai Creek Reach 14 Habitat Restoration project site near Culdesac, Idaho, and an explanation of the design process, analyses, and preliminary outcomes for the proposed enhancement design.

GeoEngineers organized the following sections of this report to describe the General Project and Data Summary Requirements required by the Bonneville Power Administration (BPA) for regulatory compliance coverage under the Habitat Improvement Program (HIP). This report is submitted to satisfy the final design step as part of the BPA Restoration Review Team (RRT) review process. BPA developed the requirements to effectively communicate that appropriate planning, analysis, design, and resulting construction documentation are met. The conditions of the project reach are described in terms of processes that shaped the stream and associated ecosystem within the context of various ecological disciplines. This includes discussions on hydrology, hydraulics, habitat, and geomorphology. The evaluation and consideration of the site conditions provide the basis for the project design.

- Appendix A—Final Design Drawings
- Appendix B—Site Photographs
- Appendix C—Hydrologic and Hydraulic Analyses
- Appendix D—Rock Weir Gradation
- Appendix E—Large Wood Stability Calculations
- Appendix F—Construction Quantities and Estimate of Anticipated Costs
- Appendix G. HIP Project Review Comment Tracking
- Appendix H—Report Limitations and Guidelines for Use

1.1. Project Responsible Parties

- The project sponsor is the Nez Perce Tribe, and the project manager is Travis House, 208.621.4739.
- The prime design consultant is GeoEngineers, Inc. and the engineer of record is Ryan S. Carnie, PE, 208.258.8326.

1.2. Site Location

The Lapwai Creek Reach 14 project site is located along U.S. Highway 95 (US 95) near milepost 285.1 on the Nez Perce Indian Reservation in Nez Perce County, Idaho, upstream (south) of Culdesac, Idaho (Vicinity Map, Figure 1). Lapwai Creek generally flows southeast to northwest towards the Clearwater River. Lapwai Creek combines with Mission Creek, Sweetwater Creek, and Tom Beall Creek prior to the confluence with Clearwater River.

2.0 PROJECT BACKGROUND

The overall intent of the project is to improve habitat conditions for native salmonids, particularly Endangered Species Act (ESA)-listed steelhead by stabilizing the channel and adding complex structure. More specifically, this project will provide improved juvenile fish rearing habitat, encourage recruitment of spawning appropriate gravels, and restore native riparian communities.

2.1. Project Goals, Objectives, and Constraints

Working in conjunction with NPT and BPA the following project goals, objectives, and constraints have been defined as follows:

2.1.1. Goal

The primary goal of the project is to provide a stable and complex channel that provides spawning and rearing habitat for ESA-listed steelhead (*Oncorhynchus mykiss*).

2.1.2. Objectives

To achieve the project goal, outlined above, the following objects have been developed:

- Increase channel complexity with channel morphology closer to historical, functional form.
- Increase quantity and quality of native fish habitat, especially cover and pools.
- Increase channel stability to limit negative impacts to US 95.
- Increase the native extent and density of the riparian community.

2.1.3. Constraints

Approximately 400 feet upstream of the project reach, a corrugated metal pipe (CMP) was projecting out of the US 95 roadway embankment on the river right bank (Photograph 8, Appendix B, Site Photographs). The culvert conveys surface water runoff from the eastern valley hillside, underneath US 95 (Appendix A, Final Design Drawings). All conceptual design components are proposed downstream of the culvert and will not impact culvert conditions, roadway embankment stability, or conveyance capacity. Additionally, the general proximity of US 95 to Lapwai Creek and its floodplain greatly impacts the overall ecological function of the stream.

Typically, streams do not have side channels or a step-pool geomorphic condition with a slope greater than 3 percent; constructed side channels create a risk of channel avulsion (WDFW 2012). The location of the existing incised main channel is consistent with a previously designed side channel. Proposed conditions should look to fill in the existing side channels and add surface roughness elements throughout the project reach's floodplain.

3.0 EXISTING CONDITIONS

3.1. Project Site

Upper limits of the project reach begin at the Idaho Transportation Department (ITD) US 95 gravel pullout along the southbound lane (Photograph 3, Appendix B). The downstream limits of the project reach are approximately 1,100 feet downstream (northwest) of the most confining point on the pullout, which is at approximate existing river station 12+50 (Appendix A).

3.1.1. Site Assessment (April 2021)

Throughout the project reach, Lapwai Creek's channel geometry has been greatly altered following peak runoff events in 2019 and 2020. On average, the existing reach has a bankfull width (BFW) of 27 feet and is approximately 4 feet deep (Photographs 1 and 2, Appendix B). Bank slopes are near vertical, a common outcome of the channel incision (Photograph 1, Appendix B). The reach currently has an average slope of 3.2 percent and an approximate sinuosity value of 1.1 (Appendix A) compared to a range of slopes between 3.3 to 6.4 percent and sinuosity of 1.3, called for in the previous design plans (Alta Science & Engineering 2018). The active floodplain width varies from 50 to 150 feet, measured between US 95's road embankment to the toe of the western valley hillslope (Appendix A).

3.1.2. Adjacent Reaches

GeoEngineers assessed a representative section of Lapwai Creek approximately 500 feet downstream of the project reach in April 2021. Compared to the incised and headcut section within the project reach, the downstream channel geometry had a greater width-to-depth ratio with a BFW of 32 feet. The downstream reach was also less incised and had a more developed riparian zone along the banks and within the floodplain (Photograph 5, Appendix B). The section downstream of the project reach included step-pool geomorphic characteristics with steps comprised of 18-inch-diameter and larger boulders. The downstream reach also included some response indicators such as depositional bars due to the continued streambed material adjusting following the of the 2019 and 2020 peak runoff events.

GeoEngineers assessed a section of Lapwai Creek starting at the upstream limits of the project reach and extending upstream approximately 800 feet. This reach included a section confined by the US 95 pullout. The channel included a depositional bar centered in the channel and split flow conditions immediately upstream of the confining pullout between approximate stations 14+50 and 16+00 (Appendix A and Photograph 3, Appendix B). Further upstream, and beyond the apparent impact of the confining highway pullout, the reach included step-pool features and depositional material within the BFW. The steps were spaced at approximately two to three bankfull widths (Photograph 4, Appendix B). We measured the BFW as approximately 25 feet. We took the measurement upstream of the channel impacted by the pullout confinement using vegetation, material size variation, and grade breaks as indicators.

3.1.3. Project Reach

The existing project reach lacks instream and floodplain large woody material (LWM). Few pieces of LWM from the 2018 restoration project remain and those pieces still on site are perched above seasonal average flows due to the channel migration and incision (Photographs 6 and 9, Appendix B). Due to the lateral channel migration that occurred in 2019 and 2020, the channel's alignment was offset from the areas of established mature deciduous and coniferous trees, decreasing the opportunities for natural wood recruitment and stream shade. Multiple high-flow side channels were present along the project reach, most likely formed prior to the channel constructed in 2018 (Photograph 7, Appendix B).

There is a distinct lack of vegetation throughout the project reach. Much of the floodplain vegetation planted during the 2018 restoration project has either eroded during peak runoff events or has not successfully been established. Few pockets of grasses and native woody shrubs have established near the edge of the current channel (Photograph 9, Appendix B); however, they are sparse and ecologically inconsequential.

3.1.4. Previous Restoration Efforts

A restoration project was previously implemented at Lapwai Creek Reach 14 in October and November 2018 (Photograph 11, Appendix B). During the spring high-flow events of 2019 and 2020, the project site experienced extensive lateral channel migration and incision along an approximate 600-foot-long section of newly constructed stream channel (Photograph 12, Appendix B). Consequently, habitat objectives were not being met and channel instability could be a threat to US 95. Additional site photographs from GeoEngineers' 2021 site assessment are included in Appendix B.

3.2. Hydrology

Lapwai Creek's watershed originates at Mason Butte, approximately 9 miles south of the project site. From Mason Butte, the river flows north through various farmlands and the town of Winchester, Idaho before entering the US 95 corridor. Through the highway corridor, Lapwai Creek drains the highway as well as the adjacent hillslopes (Watershed Map, Figure 2).

The United States Geologic Survey's (USGS) online application "StreamStats" was used to delineate watershed area for both the project site and the nearby stream gage (Gage ID 13342450) (USGS 2019). The estimated drainage basin area at the project site was 29.1 square miles, and the estimated drainage basin area at the OWRD gage was 264 square miles.

3.2.1. Peak Recurrence Interval Flows

GeoEngineers performed a hydrologic assessment of Lapwai Creek at NPT's Reach 14. Annual peak flows at the project site were estimated using the nearby USGS gage. USGS gage ID 13342450 is located along the Lapwai Creek, approximately 10 miles downstream of the project site. The peak flow analysis was performed using instantaneous flow measurements from water year 1975 to present day (up to the day of data extraction on August 3, 2021). Water years 1992, 2005, and 2006 did not include a full dataset. These years were not included in the analysis. Instantaneous flow data during water year 2021 was also not included because of the incomplete data set at the time of hydrologic analysis.

The U.S. Army Corps of Engineers, Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP) version 2.2 was used to perform a Log Pearson III (LP3) Bulletin 17C analysis (flow frequency analysis) for the Lapwai Creek at the USGS gage 13342450 location. HEC-SSP fits the stream gage record data to a LP3 statistical distribution to estimate peak flows at specified recurrence intervals (USACE 2019).

The drainage area at the Lapwai Creek Reach 14 site is smaller than the drainage area at the Lapwai Creek's stream gage. To account for this, the resulting flows were scaled to the project area using USGS' Region 3 scaling equation (USGS 2002). Peak flow results at the project site are summarized in Table 1 below. Hydrologic analysis can be seen in Appendix C, Hydrologic and Hydraulic Analyses.

3.2.2. Low-Flow Hydrology

GeoEngineers also performed a low-flow hydrologic analysis for Lapwai Creek at Reach 14 using daily flow measurements from the same USGS gage. A typical summer low flow (August 50 percent) and typical spring high flow (April 50 percent exceedance) were calculated. Low-flow design flows used to inform work zone isolation requirements during the allowed in-water work window. The resulting flows were again scaled to the project area using USGS' Region 3 scaling equation.

TABLE 1. DESIGN FLOWS

Annual Chance Probability (%)	Return Period (years)	Project Site Flow (cfs)
67	1.5	76
50	2	104
10	10	280
2	50	503
1	100	620
	August 50% Exceedance	1

3.3. Geomorphology

Lapwai Creek Reach 14 has an average thalweg slope of 3.2 percent with a valley slope of 3.5 percent (sinuosity of 1.1). Existing conditions through the reach have an average BFW of 27 feet and an average bankfull depth of 4 feet (width/depth ratio of 6.8). These values were measured from the survey completed in November 2020. Lapwai Creek's channel follows a plane bed formation with intermediate steps and pools. Wolman pebble counts were conducted by GeoEngineers during the site visit (Section 3.1.1) to help characterize the existing channel sediment gradation. The average gradation of the sediment gradation is presented in Table 2 shows a gravel/cobble mix.

TABLE 2. AVERAGE EXISTING CHANNEL SEDIMENT GRADATION

Unit	D100	D84	D50	D16
ft	0.7	0.4	0.2	0.1
in	8.4	5.1	2.6	1.3
mm	213.4	129.5	66.0	33.0

Lapwai Creek's floodplain is mostly restricted to the left bank because of the location of US 95's embankment (Photograph 12, Appendix B). Relict side channels currently exist along the left bank from the avulsion experienced in 2020 as well as remnant from the 2018 design (Alta Science & Engineering 2018).

4.0 DESIGN DEVELOPMENT

Lapwai Creek Reach 14's design development focused on stabilizing the degraded section of Lapwai Creek, while increasing the instream complexity to provide juvenile steelhead rearing habitat; increase floodplain connectivity; potential recruitment of spawning appropriate gravels; and restoring native plant communities. Proposed actions were developed following the BPA HIP Guidelines (Section 4.1). Actions involve the reconstruction of Lapwai Creek Reach 14's alignment and channel geometry, placement of instream structures, and the enhancement of riparian vegetation planting (Appendix A). Following a broad-level stream classification of the reach (Stream Type B), the design aims to meet a moderate entrenchment ratio, defined as the width of the floodprone area divided by the width of the bankfull channel, of 1.4 to 2.2 at a moderate gradient between 2 and 3.9 percent. Stream Type B tend to be riffle dominated and have pool infrequently spaced along the alignment (NRCS 2007).

4.1. HIP 4 Biological Opinion Considerations

The proposed actions for the project include the following categories of action as defined by the BPA HIP Guidelines (Bonneville Power Administration 2021).

- Category of Action: River, Stream, Floodplain and Wetland Restoration
    - **HIP Category 2a**. Improve Floodplain Connectivity
    - **HIP Category 2d**. Install Habitat-Forming Natural Material Instream Structures (Large Wood, Small Wood, and Boulders)
    - **HIP Category 2d**. Riparian and Wetland Vegetation Planting
    - **HIP Category 2f**. Channel Reconstruction

The following subsections describe the project elements designed under the responsible charge of an Idaho-licensed engineer. Each project element description will be summarized in more detail in the subsequent design stages. The general conservation measures are included on the design drawings in Appendix A.

4.2. Proposed Project Element 1: Channel and Floodplain Grading

Following the high-flow events in 2019 and 2020, Lapwai Creek Reach 14 experienced channel avulsion and downcutting that developed near vertical channel banks, disconnected the floodplain, and removed most of the instream complexity. Project element 1 will restore the reach's horizontal alignment and channel geometry. As shown within the project's plan set (Appendix A), proposed grading will occur from approximately station 3+20 to 10+00. Along the alignment, the stream profile will have an average slope of 3.3 percent. Instream grade control structures such as constructed riffles, LWM Type D structures, and rock weirs (Section 4.3) will help to stabilize the reach. Following each instream grade control structure, small pools will be constructed. Additionally, two riffle pool sequences are proposed at the upstream limits of the channel grading (Section 4.3). It is expected that natural variation will be incorporated in the grading and stream profile during construction. Specific location and elevation of each instream grade control structure can be seen in Appendix A.

During GeoEngineers' field investigation, an average BFW of 32 feet was measured downstream of the project reach (Section 3.1.2). The proposed channel bottom, 17 feet total, slopes towards to the thalweg at a slope of 1 percent. Channel banks lay outwards at a 1H:1V slope for 4 feet. From the top of bank, grading is proposed to catch the existing ground as shown in Appendix A. The distance and slope vary along the horizontal alignment. A proposed channel typical section can be seen in Appendix A. Floodplain grading has been extended to fill in the relict channels and to balance the excavation volume of the proposed channel.

4.3. Proposed Project Element 2: Instream and Floodplain Structures

Various instream and floodplain structures are proposed within the project reach. As previously mentioned, two of the structure types—LWM Type D and Rock Weir—are specifically designed to help stabilize the stream profile through the reach. The other instream structures look to increase channel complexity by forcing small local pools and promote sediment sorting. Structure log schedules and log dimensions can be seen in Tables 3 and 4 below, respectively. Additionally, racking logs, slash material, and habitat boulders are to be incorporated into the structures (Table 3). Structure details can be seen in Appendix A.

4.3.1. Structure Types

- **LWM Type A—Bank Rootwads (Small)**: Bank rootwads will create diverse fish habitat within the active channel. Rootwads should be placed along the channel bed and interact directly with all flows.
- **LWM Type B—Longitudinal Log**: Type B structures to create diverse fish habitat along the channel banks. Similar to Bank Rootwad structures, these structures look improve edge habitat and provide cover over local pools.
- **LWM Type C—Bank Rootwads (Large)**: LWM Type C structures are similar to Type A structures but include additional Type 1 logs and additional racking, slash, and habitat boulders.
- **LWM Type D—Step Turn**: This instream grade control structure is to be constructed using two Type 1 logs that are constructed with only the crown of the top log showing. This structure is also meant to rely on habitat boulders to help maintain the project reach's grade.
- **LWM Type E—Sweeper Logs**: Sweeper logs will be placed within or alongside other LWM structures to add additional hydraulic diversity by locally redirecting flow and creating scour.
- **LWM Type F—Whole Tree**: Whole trees, or buried snags, are designed to be partially buried in the channel banks, while also interacting with other instream structures. Type F structures help to slow stream velocities, encourage sediment sorting, and develop floodplain roughness.
- **LWM Type G—Floodplain Wood**: Floodplain structures are scattered throughout the project reach, outside of the active channel. The function of these structures is meant to develop additional roughness to slow down velocities during overbank flow events.
- **Rock Weir**: Rock weirs are meant to perform in a similar manner to the LWM Type D structures. These instream grade control structures are made up of only rock. In multiple instances, other LWM structures have been designed to interact and complement the rock weirs. It is anticipated that minor, local scour holes will develop at the downstream end of the rock weirs. Boulders making up the rock weirs have been designed to be stable through the 100-year flow event. The design gradation can be seen in Appendix E, Large Wood Stability Calculations.
- **Boulder Cluster**: Habitat boulders have been strategically placed along the proposed alignment. Each grouping of boulders are to be spaced between one to two channel widths apart. The increase in diversity and complexity that the habitat boulders provide are meant to collect gravel and provide high-flow refugia. Boulders making up the blusters have been designed to be stable through the 100-year flow event.
- **Constructed Riffle Pool Sequences**: Two constructed riffles are proposed at the upstream limits of the proposed channel. Each constructed riffle is designed to have a longitudinal grade of approximate 4.3 percent and to have a grade break near their upstream limits to act as a deformable grade control. The material gradation for the two constructed riffles was designed to resist incipient motion during a channel forming flow event (1.5-year) with an additional relative bed stability factor of 1.2. Therefore, they will be constructed using existing material supplemented with additional 8- to 10-inch-diameter boulders. Each riffle is positioned upstream of a pool. Each pool was designed with a pool depth approximate twice the bankfull depth and a pool length roughly equal to one BFW of 25 feet.

TABLE 3. INSTREAM AND FLOODPLAIN STRUCTURE LOG SCHEDULE

Structure Type	No. of Structures	Log Type 1	Log Type 2	Log Type 3	Racking (No.)	Slash (cy)	Habitat Boulders (ea)
A	4	2	1		4	1	4
B	5	3	1		2	1	6
C	4	5	1		6	1	10
D	2	2					10
E	4		2				
F	6			1	2	1	
G	11	3					
Total	36	80	21	6	62	19	106

TABLE 4. LOG TYPE DIMENSIONS

Log Type	Length (ft)	Minimum Dia (ft)	Maximum Dia (ft)	Average Dia (ft)	Rootwad (Y/N)	Whole Tree (Y/N)
1	30	1	1.5	1.25	Y*	N
2	30	1	1.5	1.25	N	N
3	30	1	1.5	1.25	Y*	Y
Racking	10	0.5	1	0.75	N	N

Notes:

* Rootwads must be at least 2x log DBH

4.4. Proposed Project Element 3: Riparian Vegetation Planting

The proposed revegetation plan is shown within the design drawings in Appendix A. All disturbed areas, including temporary access routes and staging areas, will be seeded with a native seed mix following construction with the exception of the current vehicular use area in the US 95 pullout.

Project site revegetation will be implemented throughout the site in all areas where disturbance occurred, including access routes. The exception to this will be the staging area that is serving as a US 95 pullout. Revegetation of the site will include willow (*Salix* sp.) and alder (*Alnus rubra*) trench planting. Trenches should be constructed such that the depth of the trench intercepts shallow groundwater. Next, stakes should be installed approximately every 1 foot within each trench, then the trench should be backfilled with native material. Stakes should be between ¾- and 1.5-inch-diameter and be of sufficient length so at least 2 inches of the stake base is submerged in shallow groundwater and extends at least 1 foot above the ground surface (see Drawings 6.0 and 6.1 in Appendix A). Additionally, stakes should be installed in and around LWM structures prior to backfilling.

Prior to completely demobilizing from the project area, seeding with a native grass mix should occur in all disturbed areas of the site. Hydroseeding or broadcast seeding methods are acceptable provided that the species composition is approved by the Nez Perce Tribe. The specific see mix will likely be based on commercially available mixes; however, a suggested mix is provided on Drawings 6.0 and 6.1 in Appendix A.

5.0 HYDRAULIC MODELING AND ANALYSIS

5.1. Model Development

GeoEngineers developed a two-dimensional hydraulic model of the project reach using the U.S. Bureau of Reclamation's Sedimentation and River Hydraulics—Two Dimension (SRH-2D) Version 3.2.3 (USBR 2017) computer program, a two-dimensional hydraulic and sediment transport numerical model (Aquaveo 2018).

5.1.1. Model Domain

The model encompasses an approximate 1,650-foot reach of Lapwai Creek including the project site. Laterally the model spans roughly 300 feet. Appendix C shows the model domain.

5.1.2. Model Elevation Surface

SRH-2D requires a topographic surface to represent bathymetric and overbank areas in the model. We obtained bathymetric survey data from Resource Specialists, Inc. (RSI) that was completed in June 2021. RSI used the survey data to develop a two-dimensional surface. We used the two-dimensional surface to prepare the existing conditions model elevation surface. GeoEngineers developed the proposed conditions model elevation surface by modifying the existing two-dimensional model elevation surface to reflect conditions described as the proposed project elements (Section 4.0).

5.1.3. Mesh Development

SRH-2D requires development of a mesh, which is a network of triangles and quadrilaterals that make up the computational cells (elements) of the model in which model results are computed. Element size is dictated through definition of node spacing within breaklines. Breaklines are created in the mesh to define important features in the surface (e.g., roads, the river channel, riverbanks, levees, etc.). GeoEngineers created an existing conditions model mesh with breaklines at the top and toe of the banks to better model rapid elevation changes. Each point in the mesh (node) has an elevation associated with it, which is defined from the topographic surface input.

5.1.4. Model Roughness

Manning's n is a parameter used in the model to represent roughness of surfaces. Manning's n values are defined within SRH-2D using coverages that define Manning's n regions with polygons. Manning's n regions throughout the existing model domain include the channel, floodplain, adjacent road and embankment, as well as the proposed conditions instream and floodplain structures. GeoEngineers used Manning's n roughness values published in V. T. Chow's Open Channel Hydraulics Manning's reference table (Chow 1959). Manning's n coverage values and extents are shown in Table 5 and Appendix C, respectively.

TABLE 5. MANNING'S N VALUES

Category	Manning's n Value
Channel	0.048
Forest	0.120
Floodplain	0.052
Road	0.011
Riprap	0.024
Instream and Floodplain Structures	0.200
Rock Weirs and Riffles	0.052

5.1.5. Boundary Conditions

The SRH-2D hydraulic model requires upstream and downstream boundary conditions. GeoEngineers defined upstream boundary conditions as an inflow boundary to introduce flow into the model (Table 1). GeoEngineers developed a downstream boundary condition as a normal depth water surface elevation calculated by SRH-2D using the digital elevation surface, a composite Manning's n, the downstream channel slope, and the design flow.

5.2. Existing Model Results

Existing hydraulic model results for this report include visual and tabular results for three peak annual flows including the 1.5-year, 2-year, and 100-year flow. Tables 6 and 7 reflect maximum cross-sectional data for water depth, velocity, shear stress, and water surface elevation values for the existing model conditions. Cross-sectional data was extracted at two cross sections upstream and downstream of the proposed elements. Specific data extraction locations can be seen in Appendix C. Visual plan-view hydraulic results for water depth, velocity, and shear stress are also presented in Appendix C.

TABLE 6. EXISTING CONDITIONS MODEL RESULTS AT UPSTREAM SECTION

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	1.7	6.7	2.9	2383.0
2-year	2.0	7.3	3.1	2383.2
100-year	3.8	12.2	7.3	2385.2

TABLE 7. EXISTING CONDITIONS MODEL RESULTS AT DOWNSTREAM SECTION

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	0.9	4.5	1.5	2351.5
2-year	1.0	5.0	1.8	2351.5
100-year	2.0	8.6	4.2	2352.5

5.3. Proposed Model Results

GeoEngineers extracted the proposed conditions hydraulic model results and included visual and tabular results for three peak annual flows including the 1.5-year, 2-year, and 100-year flow in Appendix C. Tables 6, 9, 10, and 11 reflect maximum cross-sectional data for water depth, velocity, shear stress, and water surface elevation values for the proposed conditions hydraulic model. Cross-sectional data was extracted at four cross sections. Those sections include one upstream of the project grading extent; one downstream of the project grading extent; one within the proposed project extent near the upstream limits; and one within the project extent near the downstream limits of the project reach. Specific data extraction locations can be seen in Appendix C. Visual plan-view hydraulic results for water depth, velocity, and shear stress are also presented in Appendix C.

TABLE 8. PROPOSED CONDITIONS MODEL RESULTS AT UPSTREAM SECTION

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	2.2	4.8	1.9	2383.1
2-year	2.5	5.2	2.0	2383.6
100-year	4.7	9.9	4.7	2385.7

TABLE 9. PROPOSED CONDITIONS MODEL RESULTS AT DOWNSTREAM SECTION

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	1.0	3.5	2.5	2352.0
2-year	1.1	3.8	3.0	2351.9
100-year	2.3	6.3	6.4	2353.0

TABLE 10. PROPOSED CONDITIONS MODEL RESULTS AT UPSTREAM GRADING SECTION (RIFFLE)

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	1.0	4.4	1.7	2377.6
2-year	1.2	5.0	3.0	2377.8
100-year	3.5	8.4	3.7	2380.1

TABLE 11. PROPOSED CONDITIONS MODEL RESULTS AT DOWNSTREAM GRADING SECTION (POROUS WEIR)

Flow Event	Max. Depth (ft)	Max. Velocity (ft/s)	Max. Shear Stress (lb/sf)	Max. Water Surface Elevation (ft, NAVD88)
1.5-year	1.2	3.5	1.5	2362.9
2-year	1.4	3.9	1.6	2363.1
100-year	3.3	8.4	3.6	2365.2

5.3.1. Instream and Floodplain Structure Stability

GeoEngineers completed a risk assessment for all proposed wood greater than 15 feet in length and 12 inches in diameter located within the project site (Appendix G, HP Project Review Comment Tracking). Guidance from the Bureau of Reclamation's Large Woody Material—Risk Based Design Guidelines was used to determine appropriate factor of safety (FOS) (Bureau of Reclamation 2014). Structure safety factors and reach safety factors were combined to evaluate the overall public safety risk. A risk category was based on the combined Reach User plus Structure-Specific scores. The proposed LWM structures were rated as low public safety risk. Property damage risk was evaluated using stream response potential and adjacent property and project characteristics. The proposed LWM structures were rated as moderate property risk because of the highly dynamic stream response potential and proximity to adjacent agricultural resources (Appendix E).

TABLE 12. DESIGN FACTOR OF SAFETY OF LWM STRUCTURE MEMBERS

Stability Calculation	Factor of Safety
$FOS_{sliding}$[1]	1.5
$FOS_{bouyancy}$[2]	1.75
$FOS_{rotational}$[3]	1.5

Notes:

[1] Sliding factor of safety is calculated as the ratio of resistant forces (bed friction, passive soil resistance) over driving forces (drag, rotational moment).

[2] Buoyancy factor of safety is calculated as the ratio of resistant forces (weight of log, ballast) over driving forces (buoyancy, lift force).

[3] Rotational factor of safety is calculated as the ratio of resistant forces (friction, passive soil resistance, bed friction) over driving forces (rotational moment).

Structures were designed to either be self-ballasting (stabilized by their own weight), ballasted using habitat boulders, or ballasted with bank overburden. Buoyancy was evaluated by comparing uplift forces from the logs with the weight of the structure including the weight of the wood, the weight of the logs, and soil ballast. Resistance against buoyancy from pile skin friction was calculated using methods described in Large Woody Material—Risk Based Design Guidelines (Bureau of Reclamation 2014). Stability calculations were completed using workbooks included in Appendix E. All structures are designed to be stable up to the 100-year flow event.

5.3.2. Proposed Conditions Porous Rock Weir, Boulder Cluster, and Constructed Riffle Stability

Stability of the proposed gradation for the porous rock weirs was analyzed using the Critical Shear Method (United States Forest Service 2008). The Critical Shear Method of sediment transport calculations is appropriate for channels with well-graded sediment and longitudinal slopes less than 4 percent. Maximum modeled shear stress values were extracted from SRH-2D model for the 100-year flow. Based on results of the Critical Shear Method assessment, the proposed gradation should be stable under the proposed conditions as indicated in Appendix D, Rock Weir Gradation.

We designed the proposed construction riffle material gradation to resist insipient motion during a channel-forming bankfull event (1.5-year) with a relative bed stability factor of 1.2. A relative bed stability factor represents the modeled shear stress divided by the critical shear stress for the median grain size (D_{50}) of the proposed material. We followed the Critical Shear Method outlined above and calculated a minimum D_{50} material gradation size of approximately 4.2 inches. The proposed gradation shown in Table

13 includes a mix of approximately 85 percent existing material (Table 2) and approximately 15 percent 10-inch to 12-inch rounded cobble.

TABLE 13. CONSTRUCTED RIFFLE SEDIMENT GRADATION

Unit	D100	D84	D50	D16
in	12.0	8.0	4.2	1.3

6.0 CONSTRUCTION

6.1. Disturbance Areas and Conservation Measures

Project disturbance areas are defined and shown on the design drawings in Appendix A. Conservation measures applicable to all actions are also shown on the design drawings in Appendix A.

The restored portion of the Lapwai Creek Reach 14 channel proposed in this report and shown in the plans (Appendix A) will be approximately 1,000 feet long. We used topographic/bathymetric survey data, upstream and downstream reference conditions, and the previous channel design to inform this design. Owing to the relatively narrow valley constrained by US 95 (right bank) and bedrock wall (left bank) options for locating the channel were limited. However, to the extent practical, we used portions of the existing alignment to streamline construction and minimize excavation and grading. Key features of the restored condition include:

- A single-thread channel with an average slope of 3.3 percent, average width of 25 feet, and average depth of 3 feet.
- Five rock weirs constructed with large boulders that will function as grade control in a step-pool channel morphology. These structures will be placed in the channel bed and banks and look like natural riffles.
- Six types of LWM structures will be placed in the channel and banks to provide complex habitat and also support the step-pool channel morphology. In some cases, the LWM structures will incorporate habitat boulders for additional channel complexity and structure ballast.
- Floodplain LWM will be placed outside the ordinary high water mark of the channel to add roughness in the floodplain.

To minimize disturbance to fish, construction will occur in dry conditions. To accomplish that, fish will be collected throughout the construction zone and relocated either upstream and/or downstream of the construction zone. A temporary bypass channel will be constructed adjacent to the proposed channel so water can be diverted around the construction work zone. The bypass channel will be approximately 18 feet wide and 2 feet deep to convey the anticipated flow during the in-water work period and will provide upstream and downstream passage for migrating fish throughout construction. When construction of the proposed channel is completed, water will be slowly metered into it until it is carrying the full channel flow and the bypass channel will be backfilled and blended into the natural floodplain topography.

It is anticipated that construction equipment for this project will primarily be implemented with track-mounted excavators. Track-mounted excavators will be used to shape both the proposed channel and bypass channel. Also, track-mounted excavators will be used to install the rock weirs, LWM structures, and habitat boulders. Off-road dump trucks may be used to move and distribute excavated material throughout the site and a small dozer might be used for final grading and blending in the floodplain. The proposed grading plan was developed to minimize the need for off-site export of excavated material. Variation between existing topographic surface and proposed design surface models may exist and we recommend a qualified design representative be on site during construction to provide guidance on placement of excess material.

6.2. Construction Quantities and Estimate of Anticipated Construction Costs

GeoEngineers calculated construction quantities and applied unit costs based on recent project experiences, engineering judgment, and published documentation (Oman Systems 2020). We included a summary of the anticipated construction costs in Appendix F, Construction Quantities and Estimate of Anticipated Costs.

7.0 LIMITATIONS

We have prepared this report for the Nez Perce Tribe and their authorized agents for the Lapwai Creek Reach 14 Floodplain and Habitat Restoration project.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of stream and river habitat enhancement, stabilization and restoration design engineering in this area at the time this report was prepared. The conclusions, recommendations and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty, express or implied, applies to our services and this report.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments should be considered a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

8.0 REFERENCES

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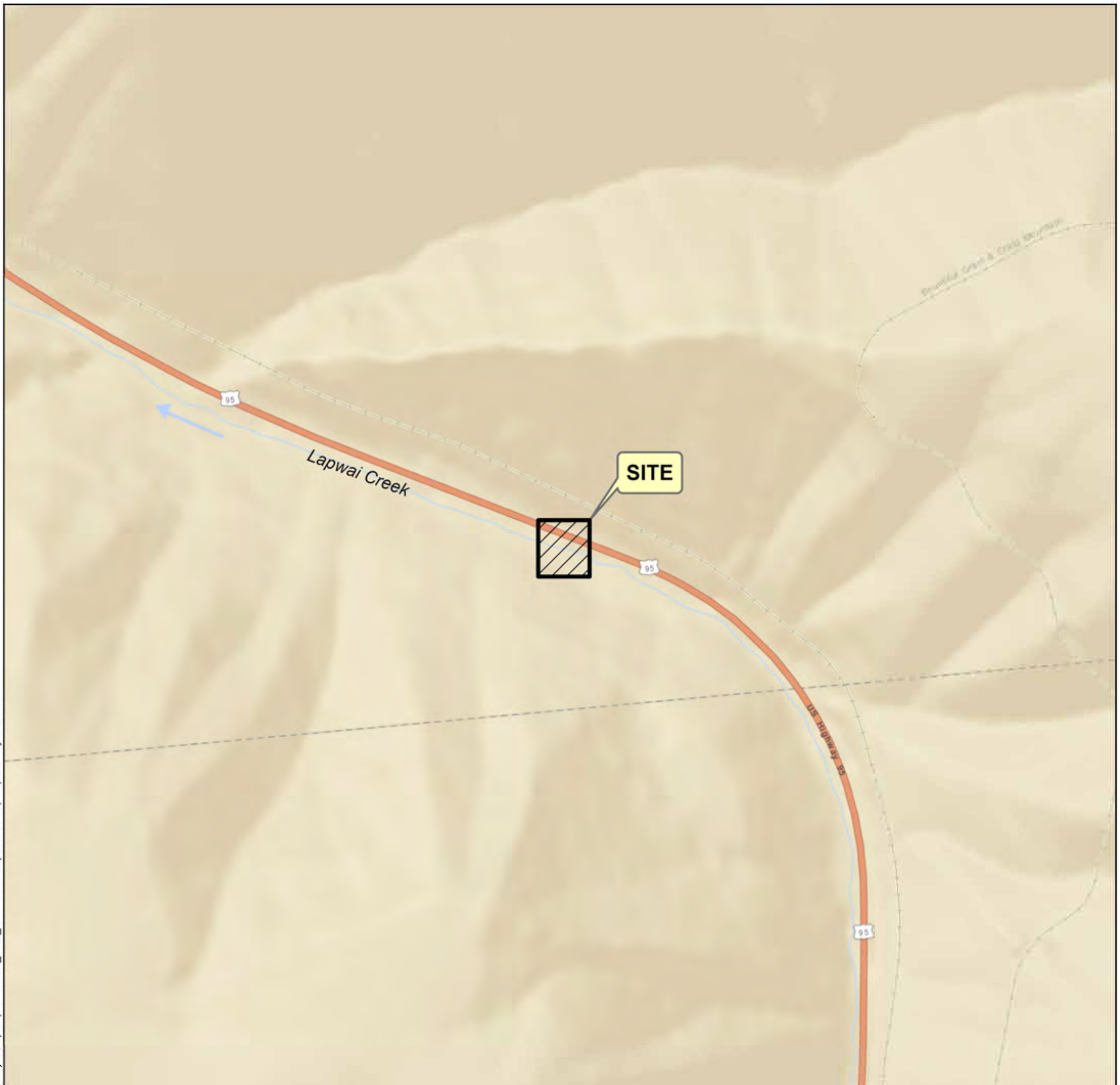
FIGURES



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Feet

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: ESRI

Projection: NAD 1983 UTM Zone 10N

Vicinity Map

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure 1

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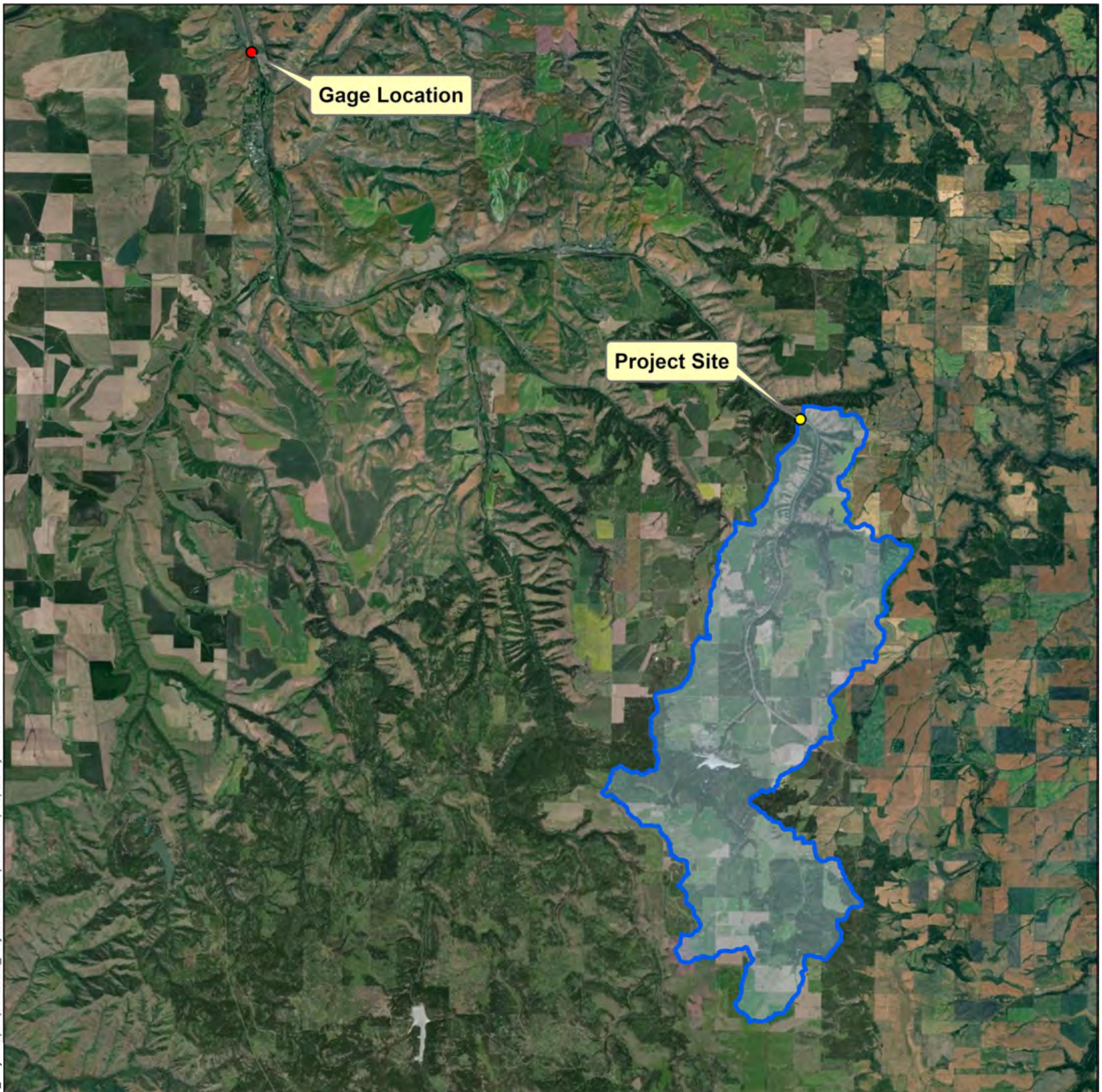

Legend

● USGS Gage ID: 13342450

● Project Site Location

▭ Site Basin

15,000 0 15,000

Feet

N W E S

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Site basin delineated by USGS StreamStats on 8/4/2021

Projection: NAD 1983 StatePlane Idaho West FIPS 1103 Feet

Drainage Basin Boundary

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure 2

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APPENDICES

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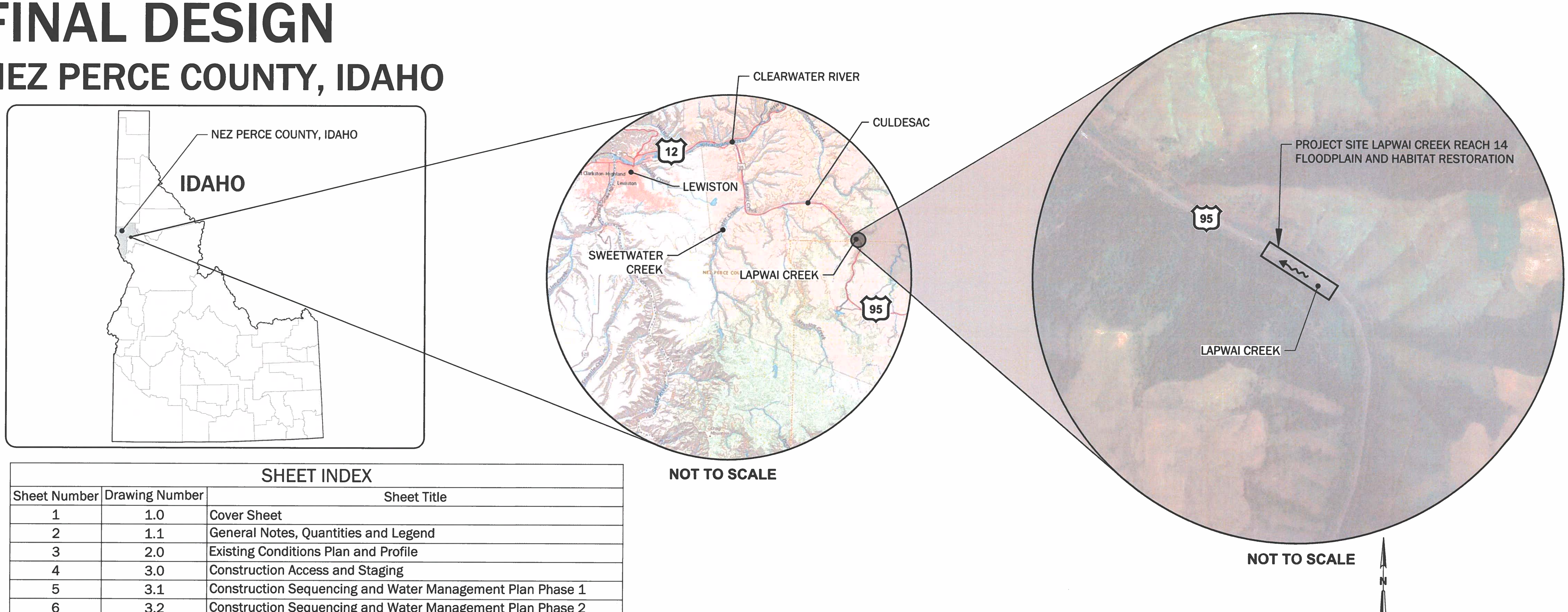
APPENDIX A
Final Design Drawings

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION FINAL DESIGN

NEZ PERCE COUNTY, IDAHO



SHEET INDEX

Sheet Number	Drawing Number	Sheet Title
1	1.0	Cover Sheet
2	1.1	General Notes, Quantities and Legend
3	2.0	Existing Conditions Plan and Profile
4	3.0	Construction Access and Staging
5	3.1	Construction Sequencing and Water Management Plan Phase 1
6	3.2	Construction Sequencing and Water Management Plan Phase 2
7	3.3	Erosion and Sediment Control Details
8	4.0	Proposed Conditions Grading Plan and Profile
9	4.1	Proposed Conditions Grading Sections and Details
10	4.2	Proposed Conditions Structures Plan
11	5.0	LWM Details 1
12	5.1	LWM Details 2
13	5.2	LWM Details 3
14	5.3	Rock Weir Details
15	5.4	Riffle Details
16	6.0	Revegetation Plan
17	6.1	Revegetation Details
18	7.0	HIP IV General Conservation Measures
19	7.1	HIP IV General Conservation Measures
20	7.2	HIP IV General Conservation Measures

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BOISE, IDAHO 83706
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811 Know what's below. Call before you dig.

PROFESSIONAL ENGINEER LICENSED 11547 STATE OF IDAHO RYAN S. CARNIE 9/29/21

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DRAWN BY: AKM/SCY
APPROVED BY: RSC
REVISION NO.: —
DATE: 09/30/2021

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PREPARED FOR: NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO
COVER SHEET

DRAWING NUMBER: 1.0
SHEET: 1 OF 20

FINAL DESIGN

Plotted: 09/29/2021, 17:17 | amorton \\geoengineers.com\WAN\Projects\0\0571022\CAD\00\Floodplain and Habitat Restoration Design\v03_100 Percent\057102200_Sht 1_1.0[Cover Sheet].dwg

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7. POTENTIAL REGULATORY CHANGES TO FLOOD ELEVATIONS AND FLOOD EXTENTS RESULTING FROM THE PROPOSED ENHANCEMENTS HAVE NOT BEEN ADDRESSED BY GEOENGINEERS AS PART OF THIS PROJECT.
8. IN GENERAL, THE PROPOSED ENHANCEMENTS ARE INTENDED TO RESULT IN MORE STABLE STREAMBEDS, BANKS AND FLOODPLAINS. HOWEVER, CHANNEL EROSION, CHANNEL MIGRATION AND/OR AVULSIONS CAN BE EXPECTED TO OCCUR OVER TIME. THESE CHANNEL PROCESSES ARE NATURAL AND APPROPRIATE FOR THESE STREAM SYSTEMS.
9. DESIGN SPECIFICS FOR STRUCTURES SHALL BE CONFIRMED AND/OR VERIFIED BY A QUALIFIED ENGINEER PRIOR TO OR DURING CONSTRUCTION AT EACH PROPOSED STRUCTURE LOCATION.
10. THESE FIGURES WERE ORIGINALLY PRODUCED IN COLOR.

CONSTRUCTION NOTES:

1. ALL CONTRACTORS WORKING WITHIN THE PROJECT BOUNDARIES ARE RESPONSIBLE FOR COMPLIANCE WITH ALL APPLICABLE SAFETY LAWS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL BARRICADES, SAFETY DEVICES AND CONTROL OF TRAFFIC WITHIN AND AROUND THE CONSTRUCTION AREA.
2. ALL MATERIAL AND WORKMANSHIP FURNISHED ON OR FOR THE PROJECT MUST MEET THE MINIMUM REQUIREMENTS OF PROJECT PERMITS, APPROVING AGENCIES, SPECIFICATIONS AS SET FORTH HEREIN, OR WHICHEVER IS MORE RESTRICTIVE.
3. ALL FEDERAL, STATE AND LOCAL PERMITS SHALL BE OBTAINED BY THE CLIENT PRIOR TO CONSTRUCTION ACTIVITY COMMENCEMENT.
4. THE CONTRACTOR SHALL INSTALL AND MAINTAIN APPROPRIATE EROSION AND SEDIMENT CONTROL DEVICES THROUGHOUT THE WHOLE PROJECT SITE, INCLUDING THOSE ASSOCIATED WITH CONSTRUCTION ACCESS, STAGING AND STOCKPILE AREAS THROUGHOUT THE PROJECT'S CONSTRUCTION PERIOD. TEMPORARY CONSTRUCTION AND PERMANENT EROSION CONTROL MEASURES SHALL BE DESIGNED, CONSTRUCTED AND MAINTAINED IN ACCORDANCE WITH ALL APPLICABLE LOCAL, STATE AND FEDERAL REGULATIONS.
5. CONSTRUCTION ACTIVITY SHALL BE LIMITED TO THE CONSTRUCTION AREAS AND ACCESS ROUTES TO MINIMIZE DISTURBANCE OF THE EXISTING VEGETATION AND LANDSCAPE. ALL PUBLIC AND PRIVATE PROPERTY EITHER INSIDE OR OUTSIDE THE CONSTRUCTION LIMITS IMPACTED BY CONSTRUCTION SHALL BE RESTORED TO A CONDITION EQUAL TO OR BETTER THAN THAT WHICH EXISTED PRIOR TO THE CONSTRUCTION. NO CONSTRUCTION-RELATED MATERIALS, DEBRIS, GARBAGE, EQUIPMENT, FUEL, PROVISIONS OF ANY KIND SHALL REMAIN ON SITE AFTER CONSTRUCTION. NO STOCKPILES OR EXCAVATIONS ARE TO REMAIN AFTER CONSTRUCTION UNLESS AUTHORIZED BY THE LANDOWNER. THE SITE WILL BE GRADED TO APPEAR NATURAL AND CONFORM TO THE NATURAL TOPOGRAPHY.
6. CONSTRUCTION SHALL MINIMIZE DISTURBANCE TO, AND MAXIMIZE REUSE OF, EXISTING RIPARIAN VEGETATION TO REMAIN AND SALVAGE.
7. ONLY APPROPRIATE APPROVED NATIVE RIPARIAN VEGETATION SHALL BE USED FOR CUTTINGS AND TRANSPLANTING. VEGETATION CUTTING, TRANSPLANTING, PLANTING AND IRRIGATION SHALL BE MANAGED BY AN APPROPRIATE PROFESSIONAL.
8. CONSTRUCTION RECORDS AND AS-BUILT INFORMATION SHALL BE ACCURATELY RECORDED BY THE CONTRACTOR AND SUPPLIED TO THE OWNER AND GEOENGINEERS, REFERENCE AND MONITORING. SUBMITTAL OF RECORD INFORMATION IS A CONDITION OF FINAL ACCEPTANCE.
9. THIS DESIGN HAS BEEN PERFORMED AND THESE PLANS HAVE BEEN PREPARED WITH THE EXPRESS UNDERSTANDING THAT GEOENGINEERS WILL BE ON-SITE DURING CONSTRUCTION TO HELP THE CONTRACT INTERPRET THE DESIGN PLANS AND INTENT.

CONSTRUCTION QUANTITIES:

Item Description	Units	No. of Units
Mobilization and Demobilization	LS	1
Erosion and Sediment Control	LS	1
Environmental Protections	LS	1
Temporary Work Area Isolation	LS	1
Temporary Stream Diversion	CY	1000
Clearing and Grubbing	AC	2
Excavation	CY	3727
Placement of Stockpiled Material	CY	3727
Riffle Cobbles (10 In - 12 in)	CY	35
In-stream structure LWM Type A	EA	4
In-stream structure LWM Type B	EA	5
In-stream structure LWM Type C	EA	4
In-stream structure LWM Type D	EA	2
In-stream structure LWM Type E	EA	4
In-stream structure LWM Type F	EA	6
In-stream structure LWM Type G	EA	11
Rock Weirs	EA	8
Boulder Clusters	EA	50
Permanent Seeding, Fertilizing Mulching and Weed Control	AC	2
Planting	EA	250

LEGEND (EXISTING)

- EXISTING MAJOR CONTOUR LINE - 5'
- EXISTING MINOR CONTOUR LINE - 1'
- LAPWAI CREEK ALIGNMENT
- PARCEL BOUNDARY
- APPROXIMATE EXISTING OWHM (1.5-YEAR FLOW)
- SURVEY BENCHMARK
- FLOW DIRECTION

LEGEND (PROPOSED)

- PROPOSED MAJOR CONTOUR LINE - 5'
- PROPOSED MINOR CONTOUR LINE - 1'
- TEMPORARY ACCESS ROUTE
- TEMPORARY STAGING LOCATION
- TEMPORARY REFUELING AND FUEL STORAGE LOCATION
- PHASE 1 AND 2 DIVERSION AREA
- PHASE 1 AND 2 PLUG AREA
- PROJECT DISTURBANCE LIMITS
- PHASE 1 AND 2 CONSTRUCTION LIMITS
- PHASE 1 AND 2 CONSTRUCTION LIMITS
- TEMPORARY ISOLATION
- SILT FENCE
- LWM - TYPE A - BANK ROOTWARDS (SMALL)
- LWM - TYPE B - LONGITUDINAL LOGS
- LWM - TYPE C - BANK ROOTWARDS (LARGE)
- LWM - TYPE D - LOG WEIR
- LWM - TYPE E - SWEEPER LOGS
- LWM - TYPE F - WHOLE TREE
- LWM - TYPE G - FLOODPLAIN WOOD
- PLANTING AREAS
- WILLOW TRENCH
- ALDER TRENCH

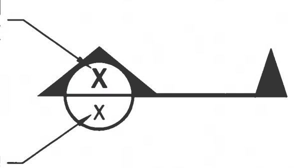
PROJECT GOAL:

THE PRIMARY GOAL OF THE PROJECT IS TO PROVIDE A STABLE AND COMPLEX CHANNEL THAT PROVIDE SPWANING AND REARING HABITAT FOR ESA-LISTED STEELHEAD (*ONCORHYNCHUS MYKISS*).

PROJECT OBJECTIVES:

TO ARCHIVE THE PROJECT GOAL, OUTLINED ABOVE, THE FOLLOWING OBJECTIVES HAVE BEEN DEVELOPED:

1. INCREASE CHANNEL COMPLEXITY WITH CHANNEL MORPHOLOGY CLOSER TO HISTORICAL, FUNCTION FORM.
2. INCREASE QUANTITY AND QUALITY OF NATIVE FISH HABITAT, ESPECIALLY COVER AND POOLS.
3. INCREASE CHANNEL STABILITY TO LIMIT NEGATIVE IMPACTS TO HWY 95.
4. INCREASE THE NATIVE EXTENT AND DENSITY OF THE RIPARIAN COMMUNITY.



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APPROVED BY: RSC
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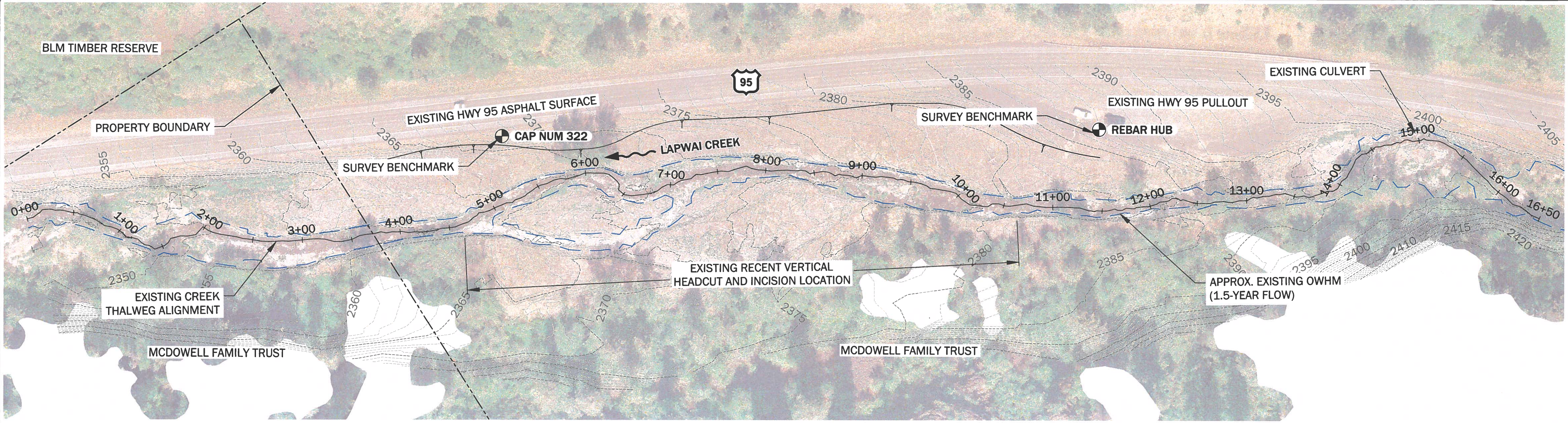
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

GENERAL NOTES, QUANTITIES AND LEGEND

DRAWING NUMBER: 1.1
SHEET: 2 OF 20

FINAL DESIGN



PLAN VIEW

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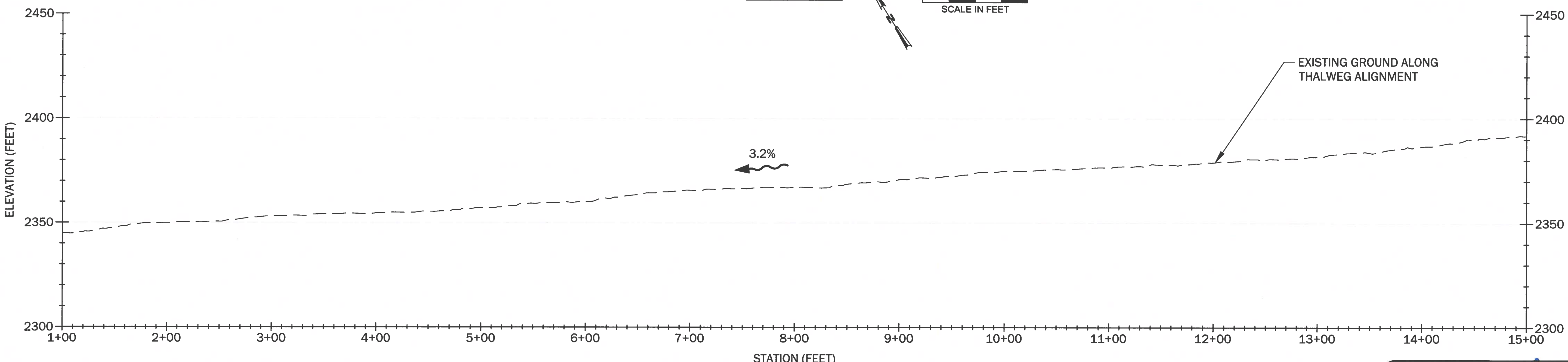
SCALE IN FEET



PROFILE VIEW

2X VERT. EXAGGERATION

0 50 100
SCALE IN FEET

SURVEY BENCHMARKS				
Point #	Elevation	Northing	Easting	Description
50	2368.61	1700373.25	2413167.06	CAP NUM 322
101	2387.90	1700056.32	2413673.18	REBAR HUB

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LICENSED
11547
STATE OF IDAHO
RYAN S. CARNIE
9/29/21

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NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

EXISTING CONDITIONS PLAN AND PROFILE

DRAWING NUMBER:
2.0
SHEET: 3 OF 20

FINAL DESIGN

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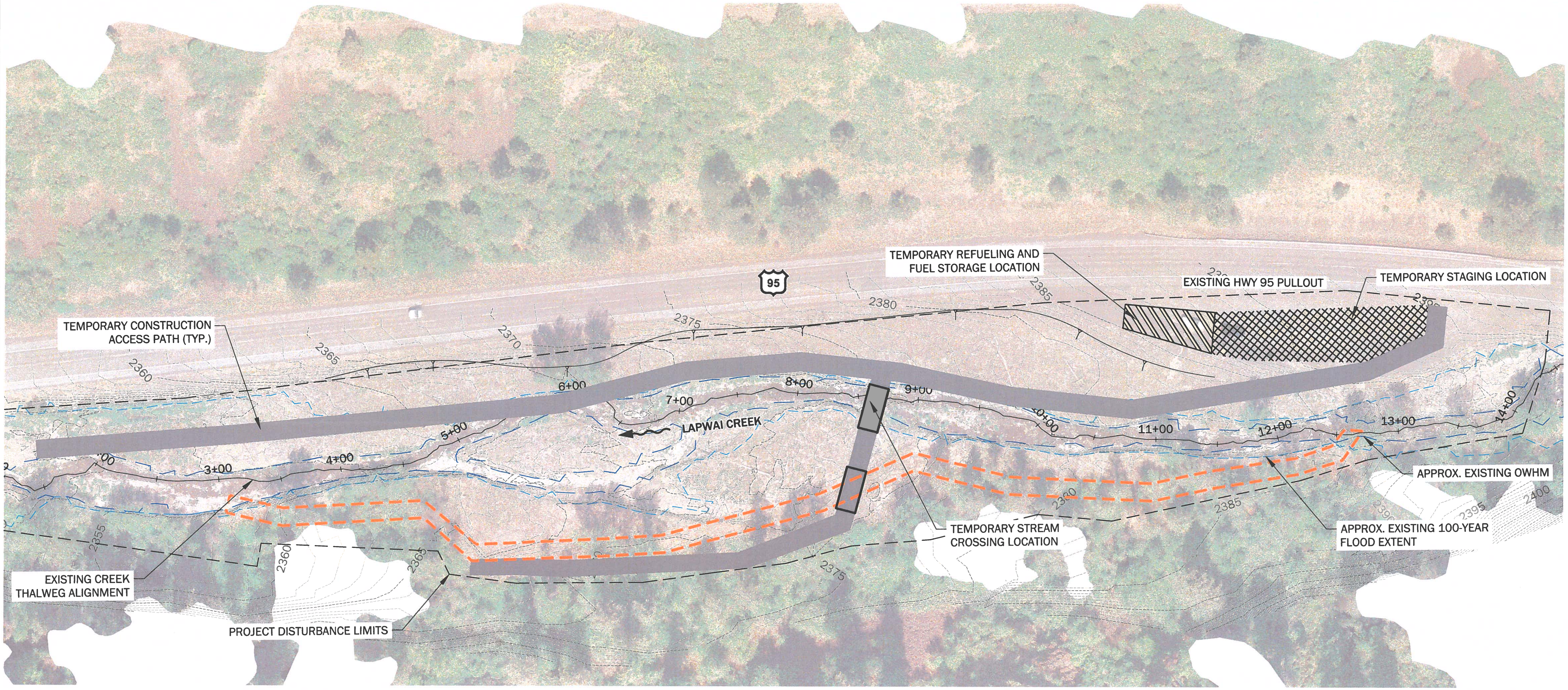

PLAN VIEW

N

0 40 80

SCALE IN FEET

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NEZ PERCE COUNTY, IDAHO

CONSTRUCTION ACCESS AND STAGING

DRAWING NUMBER:
3.0
SHEET: 4 OF 20

FINAL DESIGN

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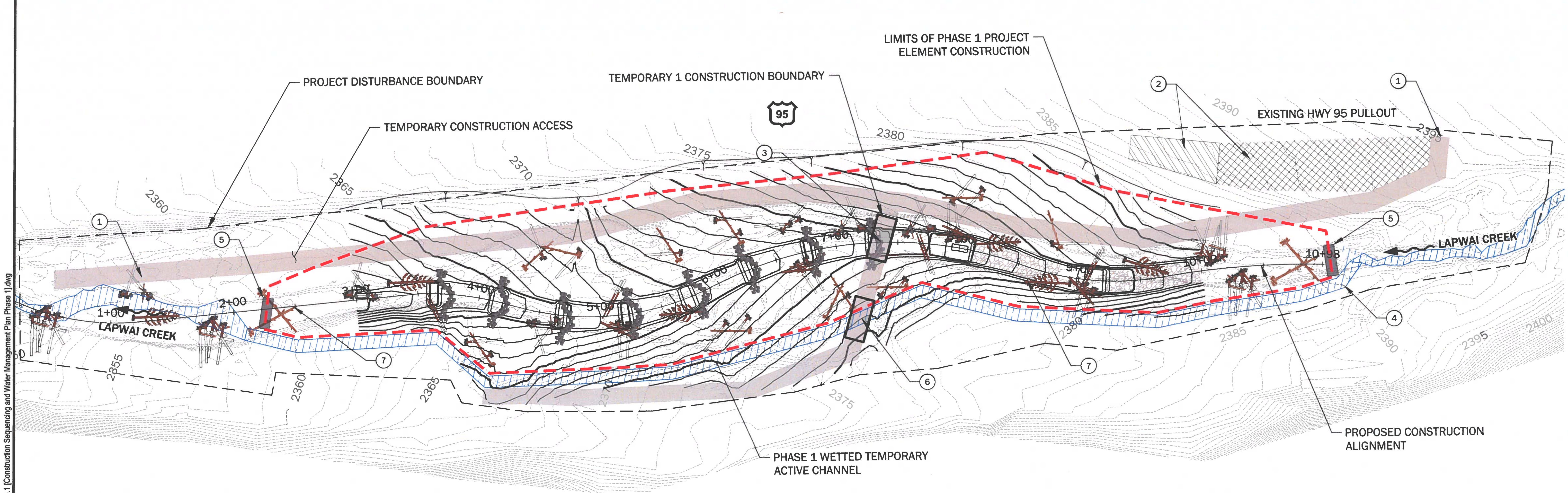


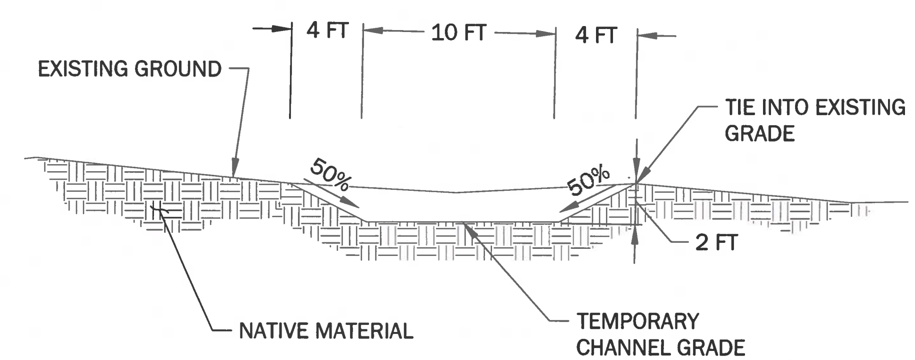
PLAN VIEW

SCALE IN FEET: 0, 40, 80

CONSTRUCTION SEQUENCING AND DEWATERING GENERAL NOTES

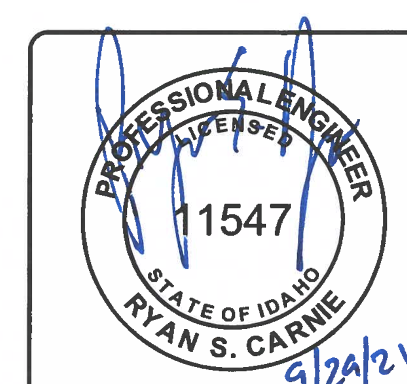
ALL IN-WATER WORK SHALL OCCUR BETWEEN JULY 1 - OCTOBER 15 OR AS OTHERWISE SPECIFIED IN ENVIRONMENTAL PERMITS.

1. ACCESS SITE FROM HIGHWAY 95. ESTABLISH TEMPORARY ACCESS ROUTES THROUGHOUT THE SITE AS SHOWN. TEMPORARY ACCESS ROUTES SHALL MINIMIZE DISTURBANCE TO NATIVE VEGETATION AND PUBLIC ROADS. HIGHWAY 95 MUST BE CLEAR OF ALL CONSTRUCTION DEBRIS AT ALL TIMES. HIGHWAY 95, PULL OUT, AND TEMPORARY ACCESS ROUTES SHALL BE RESTORED TO EXISTING CONDITION OR BETTER PRIOR TO COMPLETION OF THE PROJECT.
2. ESTABLISH STAGING AND STOCKPILE LOCATIONS AS SHOWN. ALL FUEL STORAGE AND REFUELING ACTIVES SHALL ONLY OCCUR AT THE LOCATION SHOWN ON THIS DRAWING. INSTALL PERIMETER SEDIMENT CONTROLS AROUND STAGING AREAS AND STABILIZE ANY TEMPORARY STOCKPILES. SPILL PREVENTION BEST MANAGEMENT PRACTICES SHALL INCLUDE BERMS OR DIKES TO PREVENT STORM RUNOFF FROM ENTERING STAGING AREA. CONTRACTOR SHALL HAVE ABSORBENT SPILL CLEANUP MATERIAL, DRIPS PLANS, ABSORBENT PADS AND A SPILL KIT ON SITE AT ALL TIMES THAT EQUIPMENT IS STAGED ON SITE.
3. INSTALL TEMPORARY STREAM CROSSING OVER MAIN CHANNEL WHEN ACCESSING FLOODPLAIN TO CONSTUCT TEMPROARY ACTIVE CHANNEL (SEE NOTE 4).
4. CONSTRUCT TEMPORARY ACTIVE CHANNEL WHERE SHOWN ON THIS DRAWING TO MAINTAIN FISH PASSAGE DURING CONSTRUCTION. TEMPORARY ACTIVE CHANNEL SHALL BE CONSTRUCTED PER CROSS SECTION ON THIS DRAWING. LEAVE MATERIAL PLUG AT THE INLET UNTIL FISH SALVAGE AND ISOLATION IS COMPLETED.
5. ISOLATE WORK ZONE USING A CHANNEL SPANNING FISH NET FOR CONSTRUCTION OF PROPOSED CHANNEL AND IN-STREAM STRUCTURES. CONDUCT FISH SALVAGE PRIOR TO DEWATERING. DEWATER THE ISOLATED WORK AREA AND ALLOW FOR CONTINUOUS DOWNSTREAM PASSAGE THROUGH THE DURATION OF ISOLATION. AFTER FISH SALVAGE WITHIN THE WORK AREA, CONSTRUCT TEMPORARY SOIL PLUG PER DETAIL ON SHEET 3.3 TO DIVERT LAPWAI CREEK THROUGH TEMPORARY ACTIVE CHANNEL. ANY EXCESS WATER WITHIN EXISTING CHANNEL SHALL BE PUMPED OUT AND DISCHARGED IN AN UPLAND LOCATION TO AVOID EXCESS TURBIDITY.
6. IN-STREAM CROSSINGS OF CONSTRUCTION MACHINERY SHOULD BE MINIMIZED. IF STREAM CROSSINGS ARE REQUIRED A TEMPORARY STRUCTURE SHALL BE USED TO MINIMIZED DISTURBANCE AND/OR TURBIDITY.
7. CONSTRUCT PROPOSED CHANNEL AND IN-STREAM STRUCTURES PER DRAWINGS 4.0 THROUGH 5.3.



TEMPORARY ACTIVE CHANNEL TYPICAL SECTION

NTS



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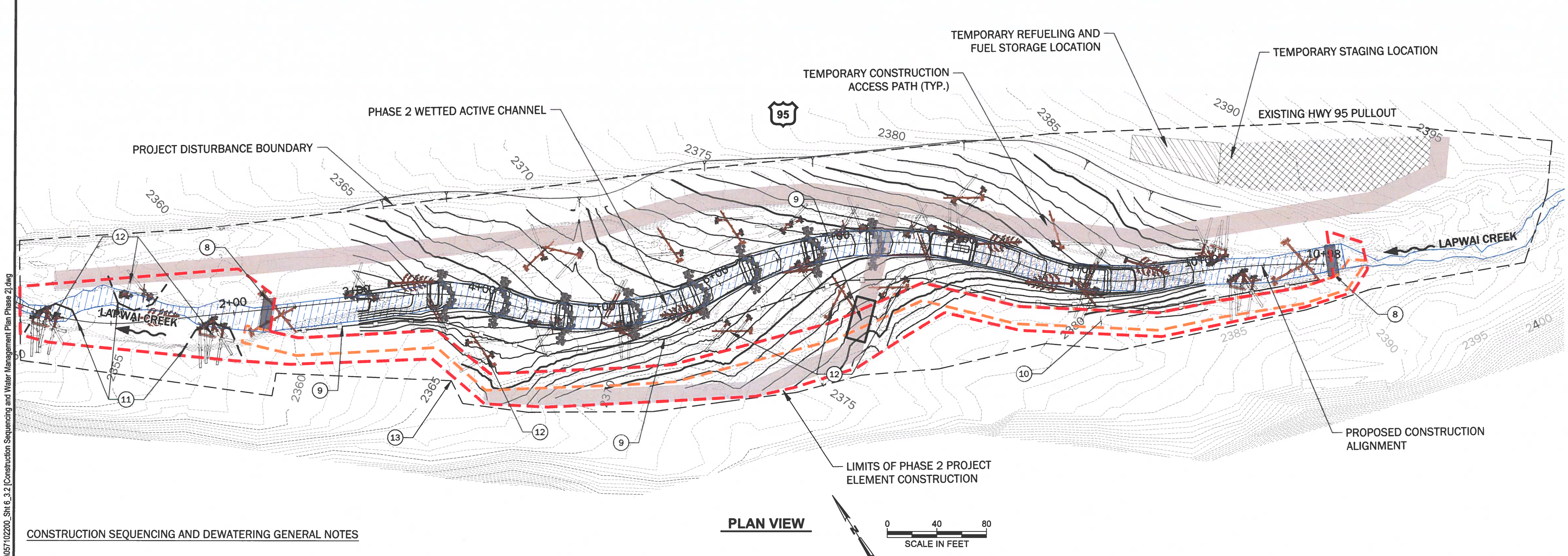
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

CONSTRUCTION SEQUENCING AND WATER MANAGEMENT PLAN PHASE 1

DRAWING NUMBER: **3.1**
SHEET: 5 OF 20

FINAL DESIGN



PLAN VIEW

CONSTRUCTION SEQUENCING AND DEWATERING GENERAL NOTES

ALL IN-WATER WORK SHALL OCCUR BETWEEN JULY 1 - OCTOBER 15 OR AS OTHERWISE SPECIFIED IN ENVIRONMENTAL PERMITS.

(8) FOLLOWING THE CONSTRUCTION OF THE PROPOSED CHANNEL AND PROJECT ELEMENTS SHOWN ON DRAWING 3.1, ISOLATE TEMPORARY ACTIVE CHANNEL (DRAWING 3.1). CONDUCT FISH SALVAGE PRIOR TO DEWATERING. REMOVE TEMPORARY SOIL PLUG FROM THE MAIN CHANNEL SLOWLY TO DIVERT FLOW FROM THE TEMPORARY MAIN CHANNEL INTO THE PROPOSED ACTIVE CHANNEL. ACTIVATION OF THE PROPOSED MAIN CHANNEL SHALL BE COMPLETED IN A MANOR TO PREVENT EXCESSIVE TURBIDITY AND SCOUR OF THE PROPOSED GRADING AND/OR STRUCTURES. ANY EXCESS WATER WITHIN TEMPORARY ACTIVE CHANNEL SHALL BE PUMPED OUT AND DISCHARGED IN AN UPLAND LOCATION TO AVOID EXCESS TURBIDITY.

(9) INSTALL TEMPORARY CHANNEL CROSSING OVER CONSTRUCTED ACTIVE CHANNEL. INSTALL SILT FENCE BETWEEN TEMPORARY AND PROPOSED MAIN CHANNELS.

(10) BACKFILL TEMPORARY ACTIVE CHANNEL WITH NATIVE MATERIAL. GRADE FLOODPLAIN SLOPES TOWARDS PROPOSED MAIN CHANNEL.

(11) ISOLATE DOWNSTREAM IN-STREAM STRUCTURES PER DETAIL ON DRAWING 3.3. PRIOR TO CONSTRUCTION OF THE LWM STRUCTURES, CONDUCT FISH SALVAGE.

(12) CONSTRUCT IN-STREAM STRUCTURES PER DRAWINGS 4.0 THROUGH 5.4.

(13) RESTORE DISTURBED AREAS WITHIN THE FLOODPLAIN GRADING LIMITS ACCORDING TO THE REVEGETATION PLAN AND DETAILS PER DRAWINGS 6.0 AND 6.1 AFTER CHANNEL GRADING AND IN-STREAM STRUCTURE INSTALLATION IS COMPLETE. ALL DISTURBED AREAS SHALL BE RESTORED TO EXISTING CONDITIONS OR BETTER.

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DATE: 09/30/2021

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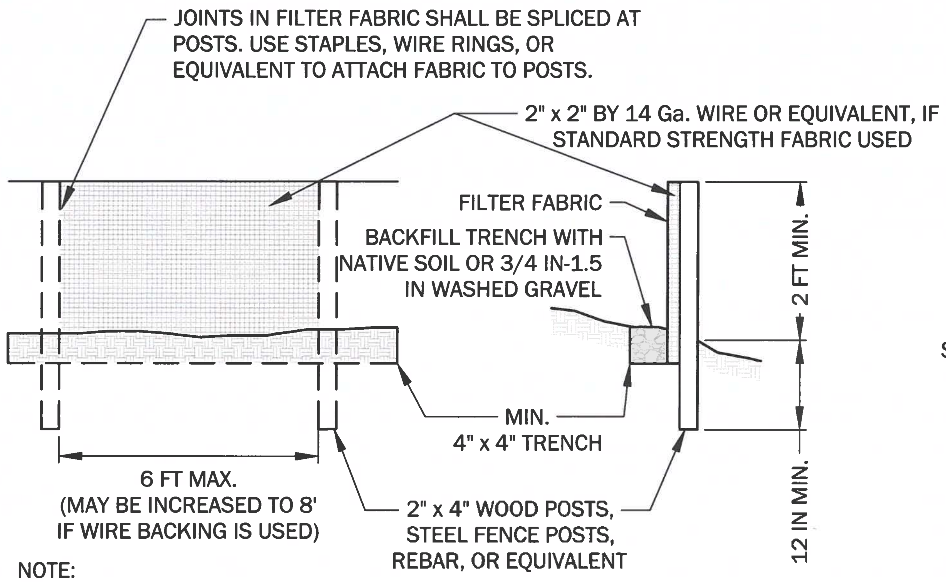
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO
CONSTRUCTION SEQUENCING AND WATER MANAGEMENT PLAN PHASE 2

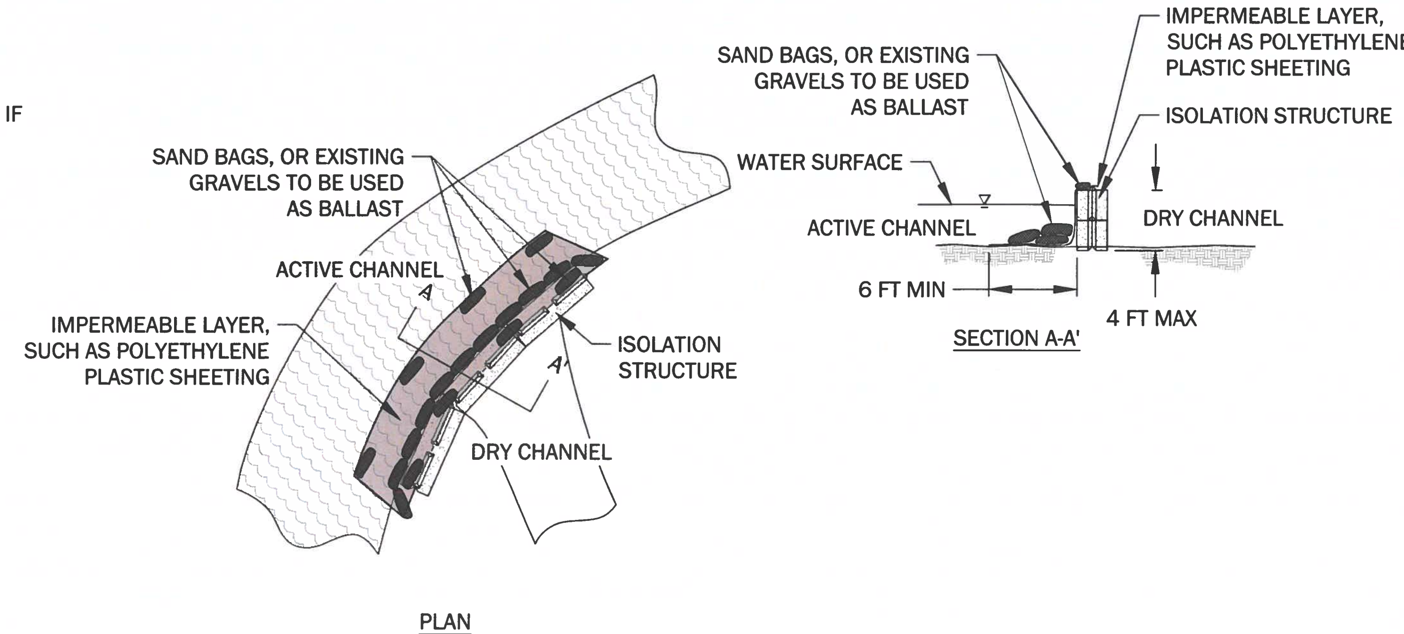
DRAWING NUMBER: **3.2**
SHEET: 6 OF 20

FINAL DESIGN



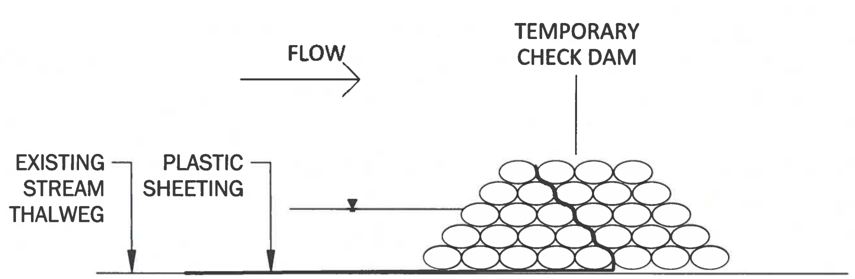
NOTE:
1. FILTER FABRIC FENCES SHALL BE INSTALLED ALONG CONTOUR WHENEVER POSSIBLE.

SEDIMENT FENCE DETAIL 1/3.3
SCALE: NOT TO SCALE



WORK ZONE ISOLATION STRUCTURE 2/3.3
SCALE: NOT TO SCALE

NOTES:
1. SEDIMENT FENCE TO HAVE STITCHED LOOPS AROUND 2" x 2" POSTS.
2. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
3. 3'MIN x 2" x 2" FIR, PINE OR STEEL FENCE POSTS.
4. POSTS TO BE INSTALLED ON UPHILL SIDE OF SLOPE.
5. COMPACT BOTH SIDES OF FILTER FABRIC TRENCH.



NOTE:
TEMPORARY CHECK DAM SOIL PLUG SHALL BE CONSTRUCTED WITH EXCAVATED NATIVE MATERIAL

TEMPORARY SOIL PLUG 3/3.3
SCALE: NOT TO SCALE

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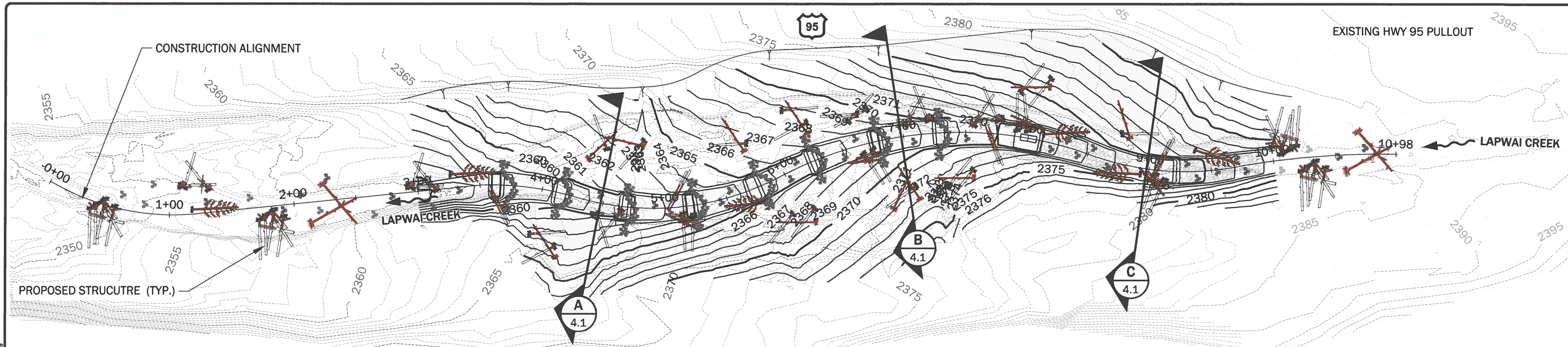
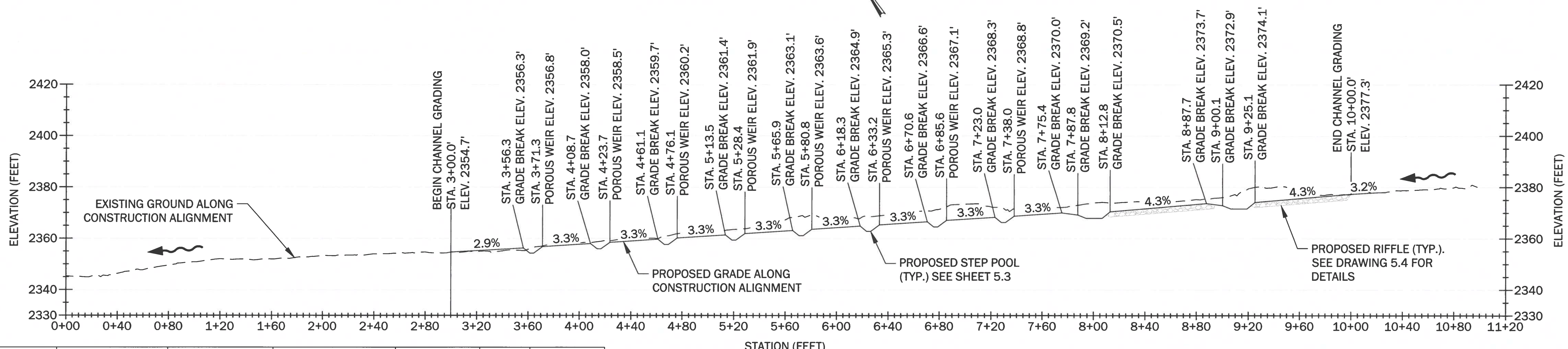
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO
EROSION AND SEDIMENT CONTROL DETAILS

DRAWING NUMBER: 3.3
SHEET: 7 OF 20

FINAL DESIGN



PLAN VIEW



PROFILE VIEW

2X VERT. EXAGGERATION

0 40 80
SCALE IN FEET

Start Station	Start Northing (FT)	Start Easting (FT)	Line/Chord Direction	Curve Radius	Length	End Station
-0+00	1700512.0	2412787.3	S45° 07' 54.55"E	193	124.4	1+24
1+24	1700425.7	2412874.0	S63° 19' 19.85"E	120	1.0	1+25
1+25	1700425.3	2412874.8	S63° 03' 21.82"E	185308	226.0	3+51
3+51	1700322.9	2413076.3	S49° 49' 07.72"E	245	78.2	4+30
4+30	1700272.6	2413135.9	S63° 23' 25.74"E	216	167.4	5+97
5+97	1700199.5	2413281.8	S61° 48' 43.33"E	312	248.1	8+45
8+45	1700085.4	2413494.7	S52° 25' 20.79"E	223	130.3	9+75
9+75	1700007.1	2413596.5	S61° 33' 46.42"E	666	122.7	10+98

CONSTRUCTION ALIGNMENT STAKING TABLE

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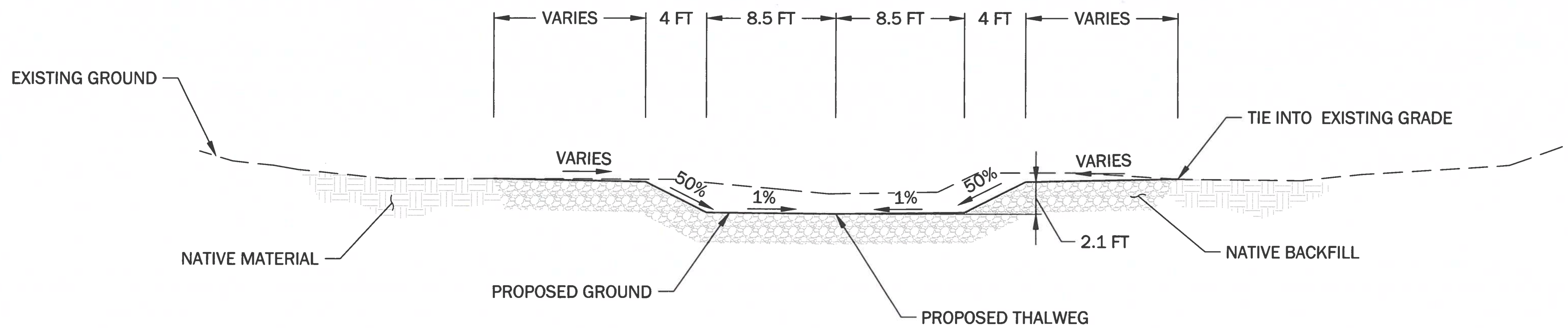
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

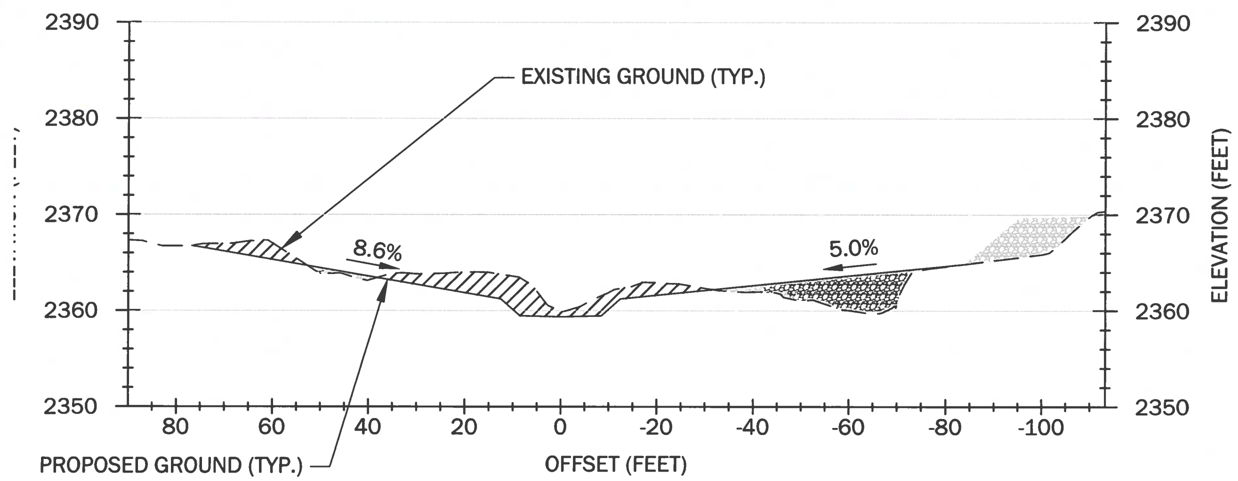
PROPOSED CONDITIONS GRADING PLAN AND PROFILE

DRAWING NUMBER: **4.0**
SHEET: 8 OF 20

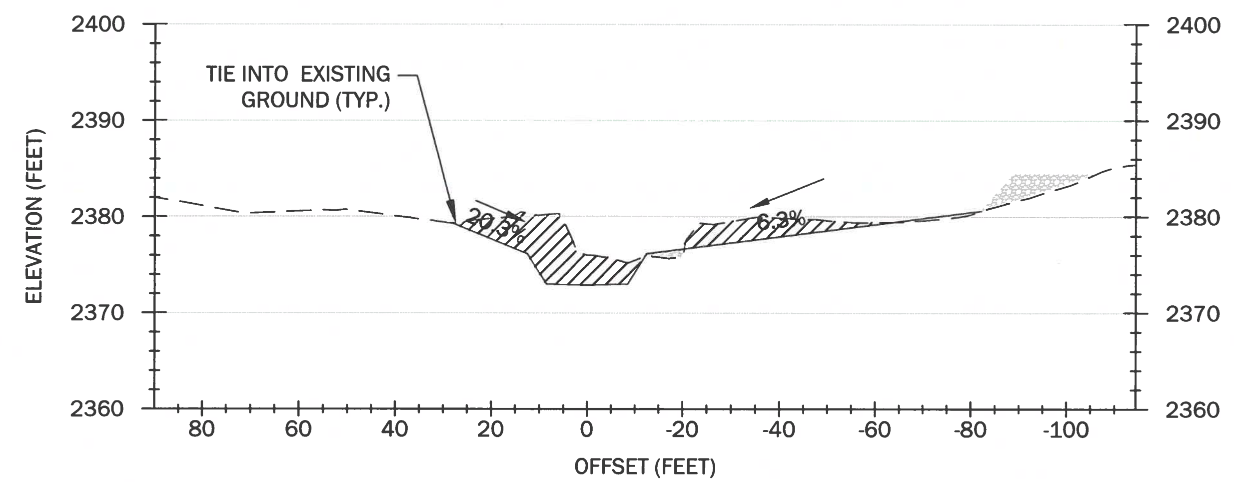
FINAL DESIGN



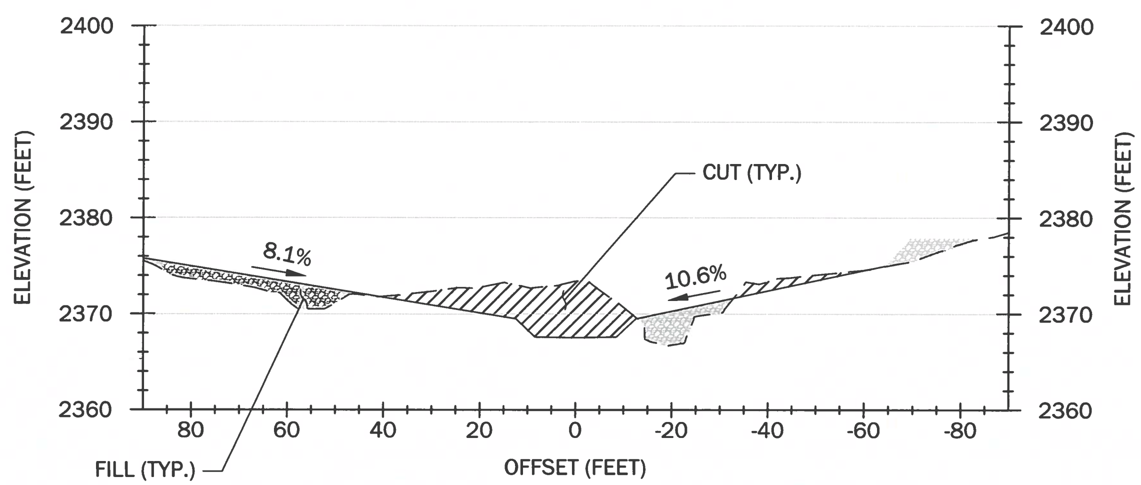
PROPOSED CHANNEL TYPICAL SECTION
NOT TO SCALE



PROPOSED CHANNEL SECTION AT STA. 4+50 (A / 4.0)
SCALE: 1" = 20' (2X VERT. EXAGGERATION)



PROPOSED CHANNEL SECTION AT STA. 9+00 (C / 4.0)
SCALE: 1" = 20' (2X VERT. EXAGGERATION)



PROPOSED CHANNEL SECTION AT STA. 7+00 (B / 4.0)
SCALE: 1" = 20' (2X VERT. EXAGGERATION)

GENERAL NOTES:
1. ALL SECTIONS FACE DOWNSTREAM.
2. GRADE FLOODPLAIN BENCHES TO PROMOTE POSITIVE FLOW TOWARDS CHANNEL THALWEG.
3. ANY AND ALL NON-NATIVE MATERIAL SHALL BE HAULED OFF-SITE AND DISPOSED OF ACCORDINGLY.

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RYAN S. CARNIE
9/29/21

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NEZ PERCE COUNTY, IDAHO
PROPOSED CONDITIONS GRADING SECTIONS AND DETAILS

DRAWING NUMBER:
4.1
SHEET: 9 OF 20

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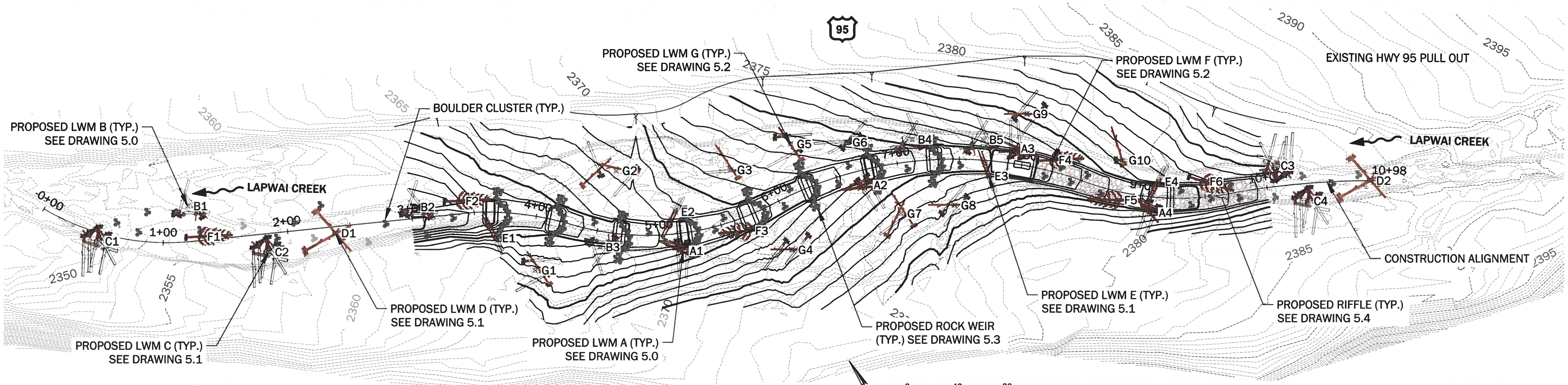

PLAN VIEW

SURVEY CONTROL POINTS

STRUCTURE #	STRUCTURE ID	NORTHING	EASTING
1	A1	1700207.27	2413199.20
2	A2	1700171.59	2413351.32
3	A3	1700132.30	2413466.05
4	A4	1700029.75	2413531.06
5	B1	1700451.96	2412884.97
6	B2	1700352.95	2413037.32
7	B3	1700245.83	2413144.72
8	B4	1700182.81	2413401.18
9	B5	1700151.59	2413448.98
10	C1	1700466.76	2412810.26
11	C2	1700386.03	2412919.85
12	C3	1700008.63	2413633.38
13	C4	1699970.48	2413640.39
14	D1	1700369.73	2412972.73
15	D2	1699957.03	2413691.76
16	E1	1700296.74	2413078.80
17	E2	1700236.73	2413210.66
18	E3	1700125.08	2413437.12
19	E4	1700047.74	2413548.99
20	F1	1700425.50	2412881.13

SURVEY CONTROL POINTS

STRUCTURE #	STRUCTURE ID	NORTHING	EASTING
21	F2	1700337.47	2413070.24
22	F3	1700192.02	2413252.38
23	F4	1700107.99	2413486.88
24	F5	1700052.69	2413513.92
25	F6	1700028.49	2413579.09
26	G1	1700258.17	2413091.28
27	G2	1700289.93	2413188.48
28	G3	1700240.86	2413266.09
29	G4	1700160.75	2413272.88
30	G5	1700232.40	2413317.47
31	G6	1700209.39	2413355.66
32	G7	1700137.85	2413361.77
33	G8	1700120.11	2413401.61
34	G9	1700150.12	2413489.37
35	G10	1700077.75	2413533.65

STRUCTURE STAKING TABLE

STRUCTURE TYPE	STRUCTURE DESCRIPTION	NO. OF STRUCTURES	LOG TYPE 1	LOG TYPE 2	LOG TYPE 3	RACKING (NO.)	SLASH (CY)	Habitat Boulders (EA)
A	BANK ROOTWARDS (SMALL)	3	2	1		4	1	4
B	LONGITUDINAL LOG	4	3	1		2	1	6
C	BANK ROOTWARDS (LARGE)	4	5	1		6	1	10
D	LOG WEIR	4		2				15
E	SWEEPER LOGS	4		2				
F	WHOLE TREE	6			1	2	1	
G	FLOODPLAIN WOOD	10	3					
	TOTAL	35	68	27	6	56	17	136

LWM SCHEDULE

LOG TYPE	LENGTH (FT)	MIN. DIA (FT)	MAX. DIA (FT)	AVG. DIA (FT)	ROOTWAD (Y/N)	WHOLE TREE (Y/N)
1	30	1	1.5	1.25	Y	N
2	30	1	1.5	1.25	N	N
3	30	1	1.5	1.25	Y	Y
RACKING	10	0.5	1	0.75	N	N

LOG SIZING TABLE

NOTE:
ROOTWADS MUST BE AT LEAST 2X LOG DBH

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FINAL DESIGN

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LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

PROPOSED CONDITIONS STRUCTURES PLAN

DRAWING NUMBER:
4.2
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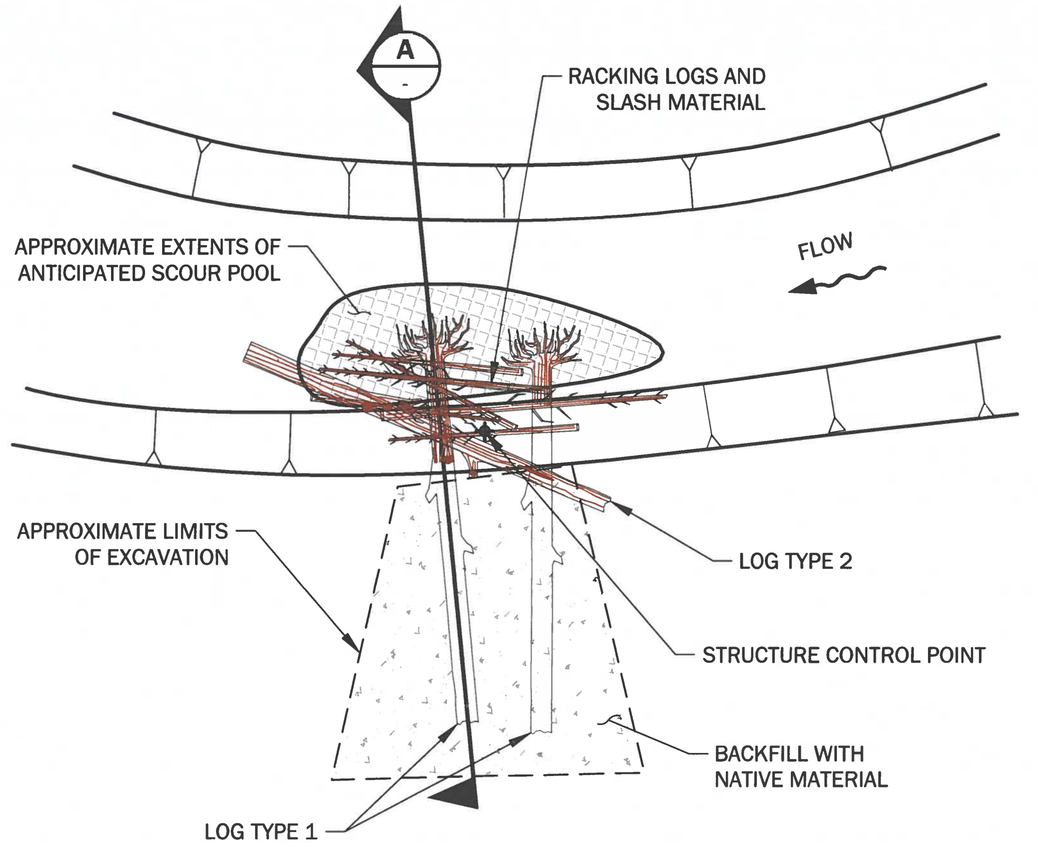
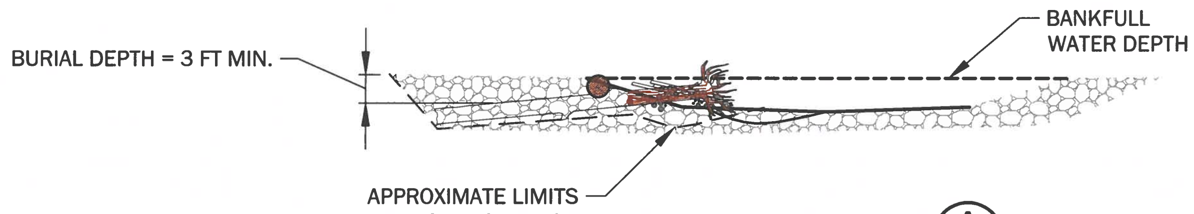
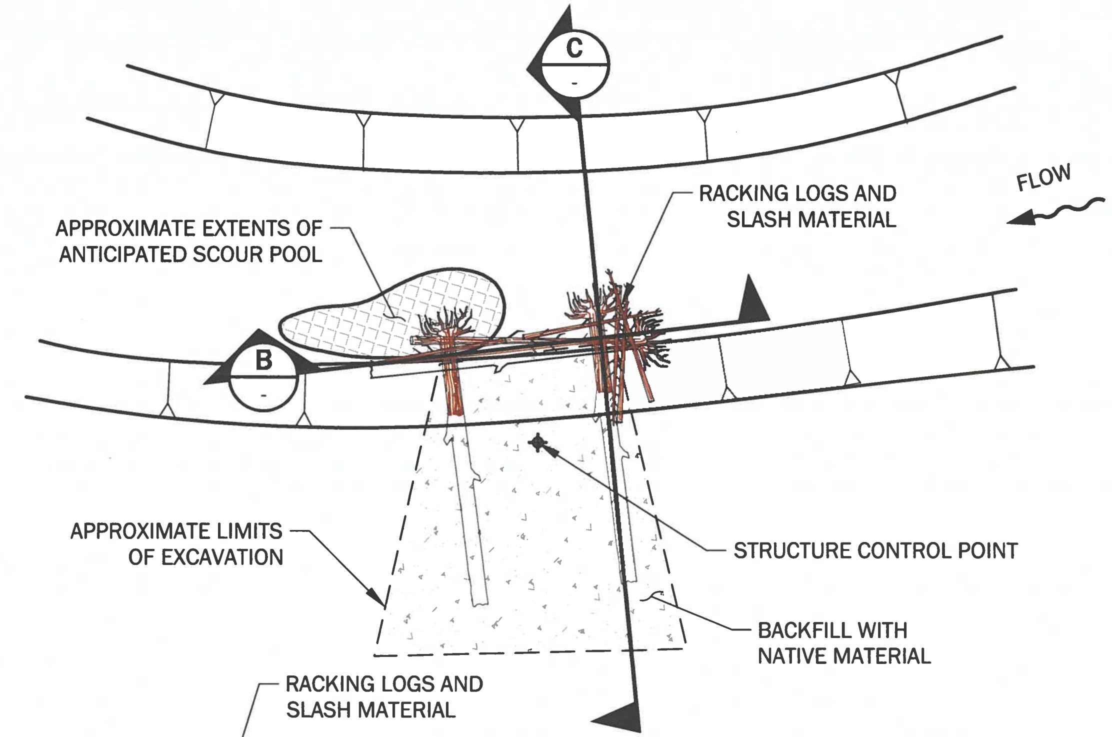


PLAN VIEW

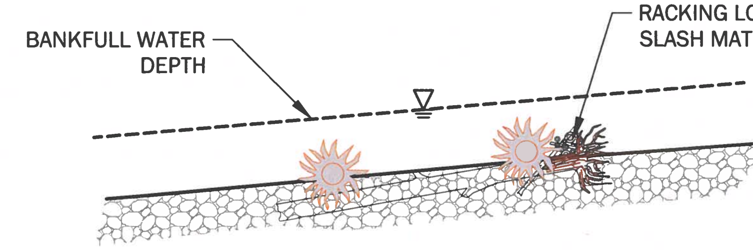


SECTION VIEW A
SCALE: NTS

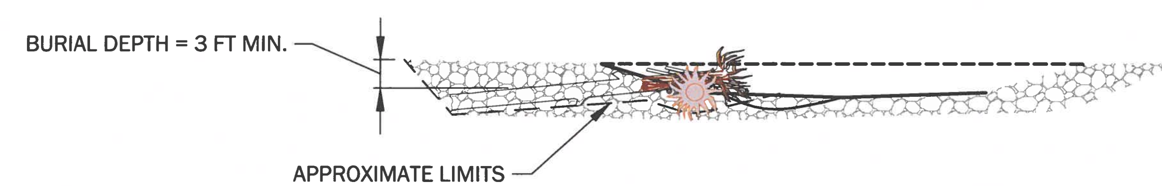
LWM TYPE A - BANK ROOTWADS (SMALL) DETAIL



PLAN VIEW



SECTION VIEW B
SCALE: NTS



SECTION VIEW C
SCALE: NTS

LWM TYPE B - LONGITUDINAL LOG DETAIL

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LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

LWM DETAILS 1

DRAWING NUMBER: 5.0
SHEET: 11 OF 20

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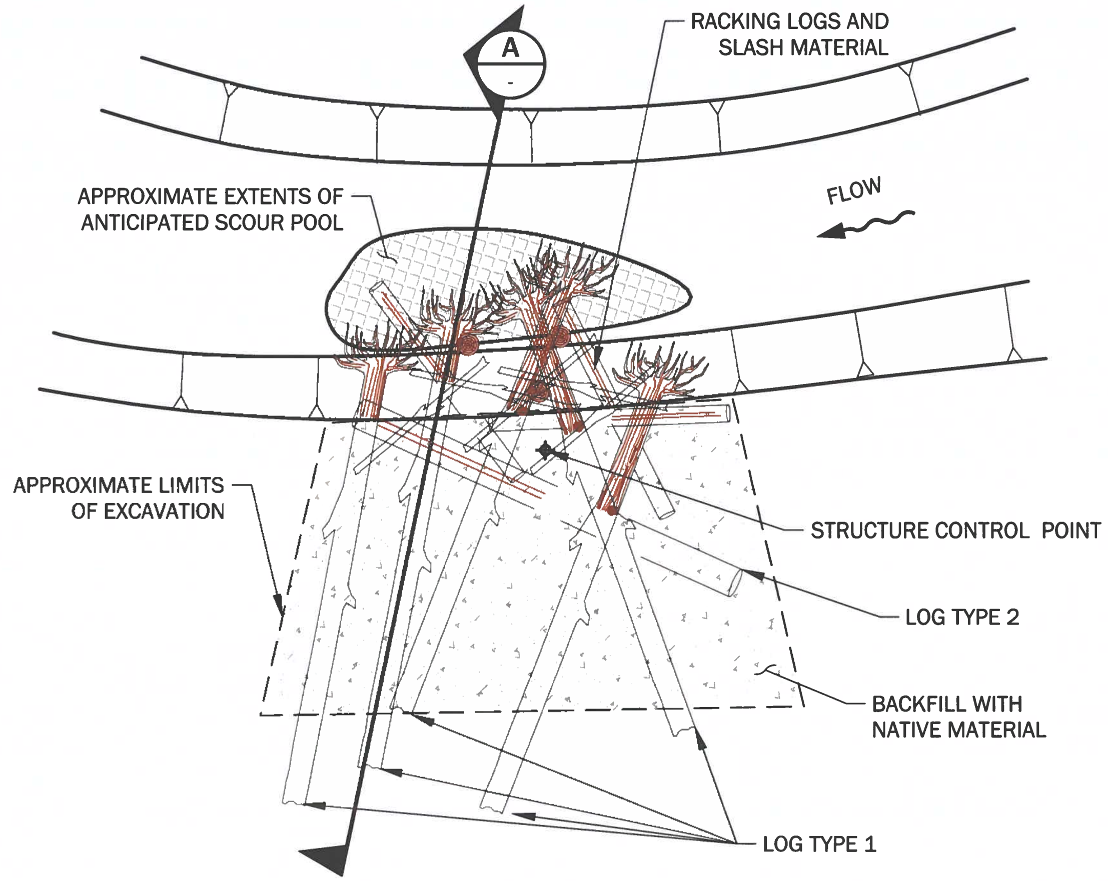
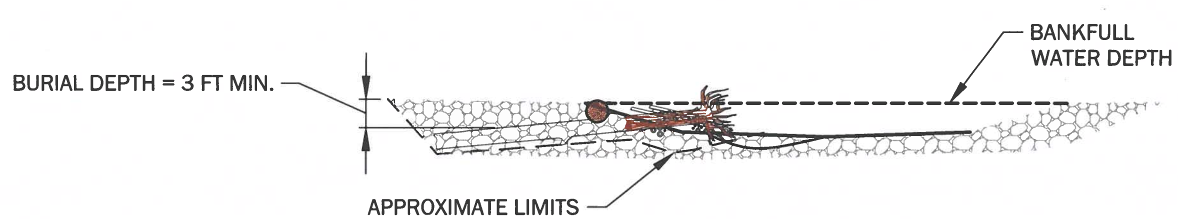
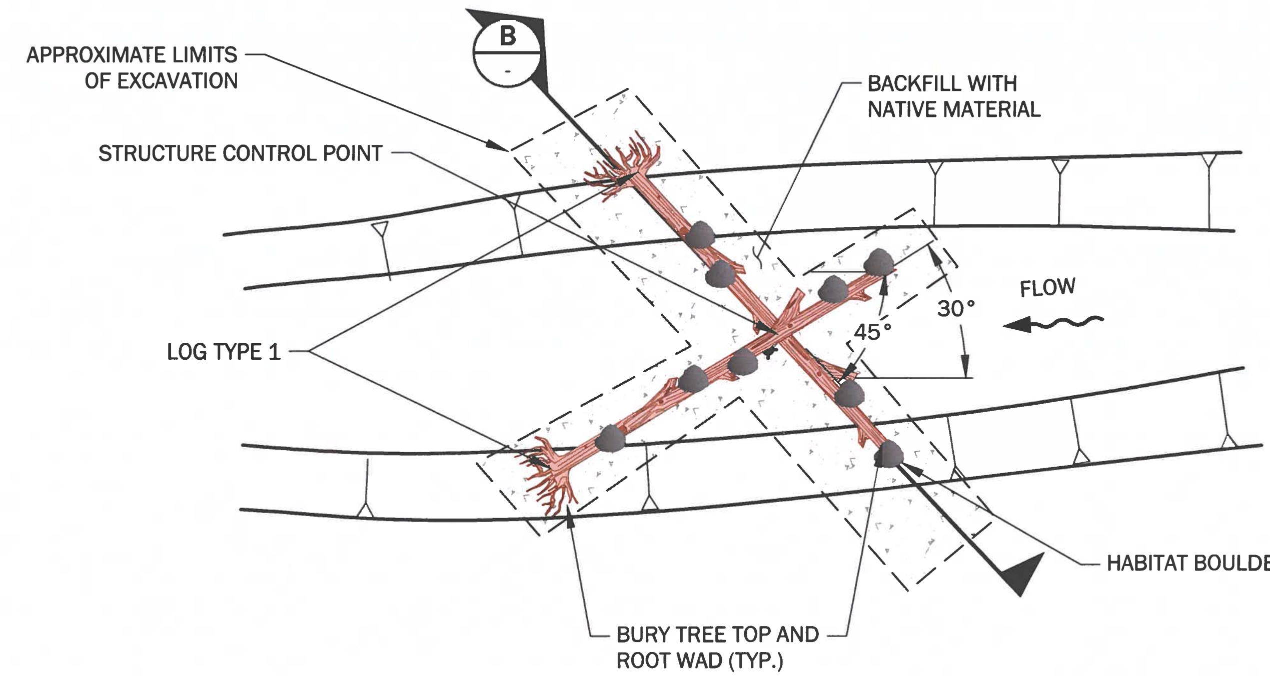
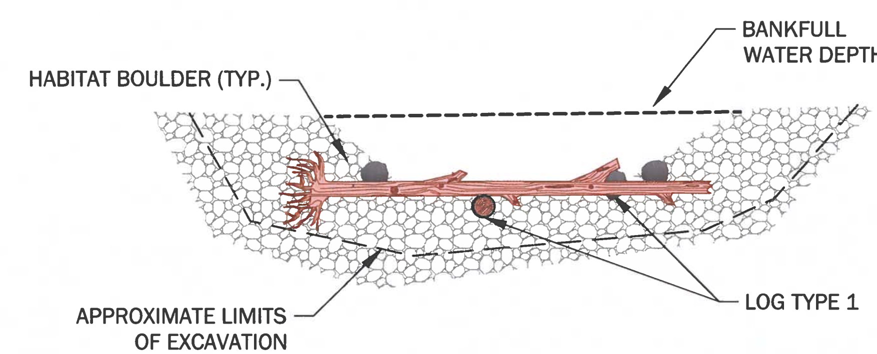




SECTION VIEW A
SCALE: NTS

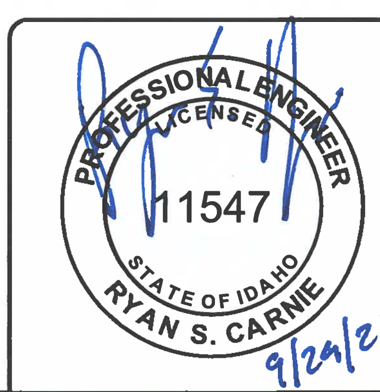
LWM TYPE C - BANK ROOTWADS (LARGE) DETAIL





SECTION VIEW B
SCALE: NTS

LWM TYPE D - STEP TURN DETAIL



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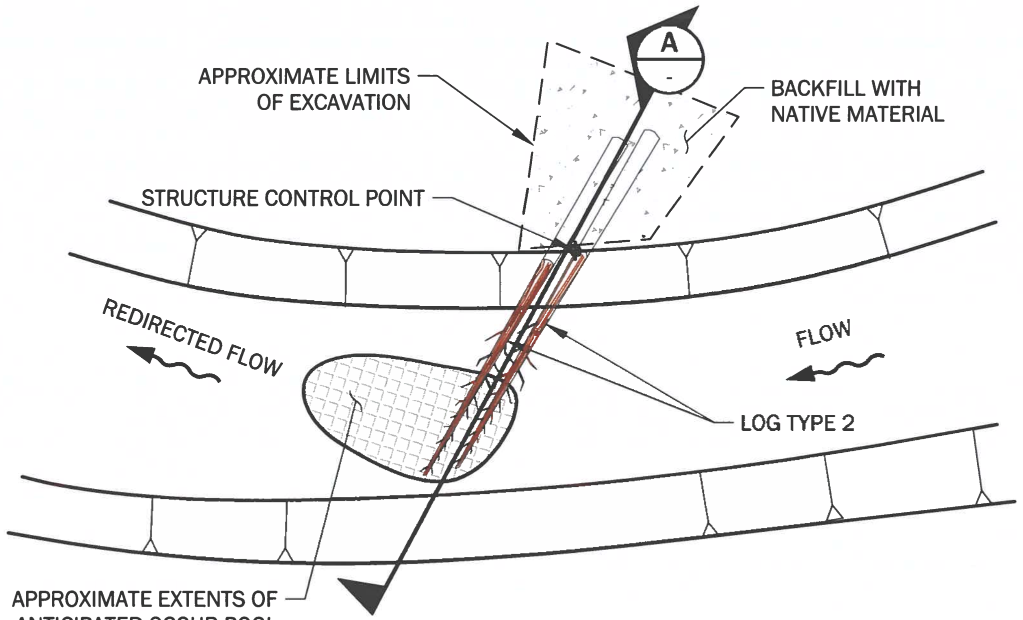
NEZ PERCE COUNTY, IDAHO

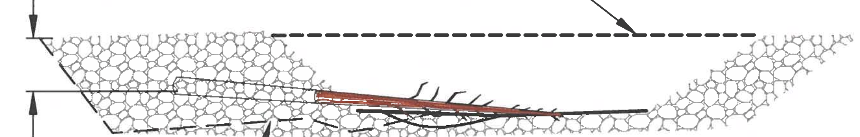
LWM DETAILS 2

DRAWING NUMBER: 5.1
SHEET: 12 OF 20

FINAL DESIGN

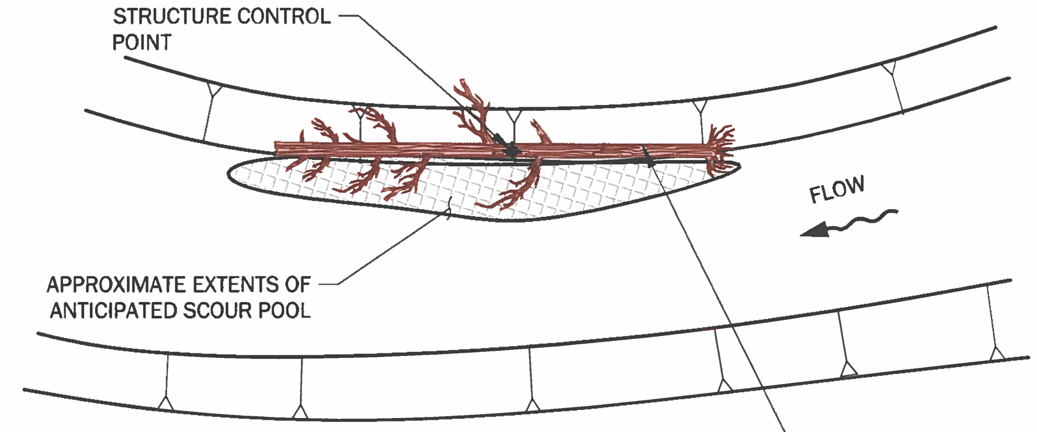


PLAN VIEW

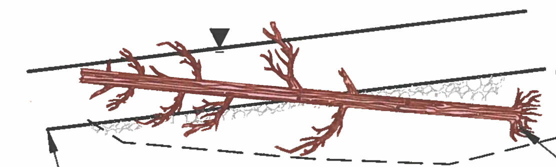


SECTION VIEW A -
SCALE: NTS

LWM TYPE E - SWEEPER LOGS DETAIL

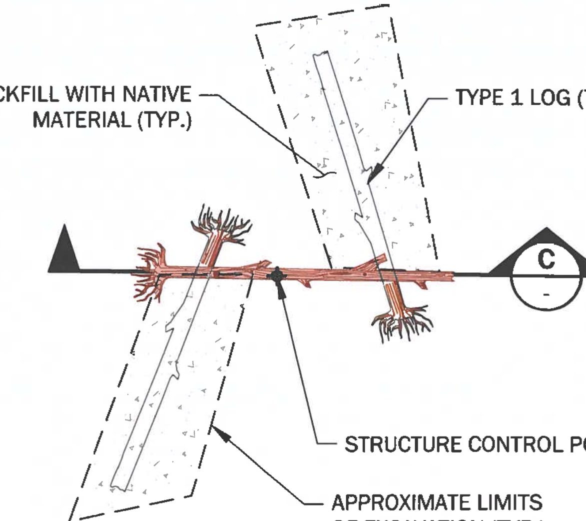


PLAN VIEW

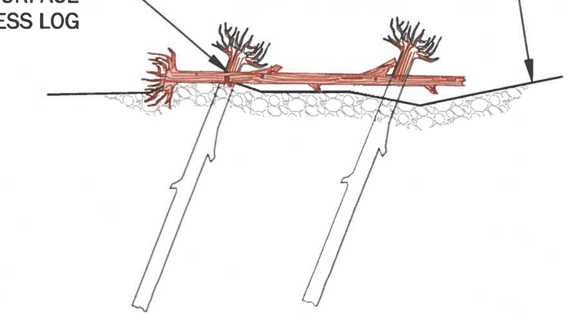


PROFILE VIEW

LWM TYPE F - WHOLE TREE DETAIL



PLAN VIEW



SECTION VIEW C -
SCALE: NTS

LWM TYPE G - FLOODPLAIN WOOD DETAIL

PROFESSIONAL ENGINEER LICENSED 11547 STATE OF IDAHO RYAN S. CARNIE 9/29/21

NO.	DATE	BY	ISSUE / DESCRIPTION

DESIGNED BY: AKM
DRAWN BY: AKM/SCY
APPROVED BY: RSC
REVISION NO.: ---
DATE: 09/30/2021

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PREPARED FOR: NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

LWM DETAILS 3

DRAWING NUMBER: **5.2**
SHEET: 13 OF 20

FINAL DESIGN

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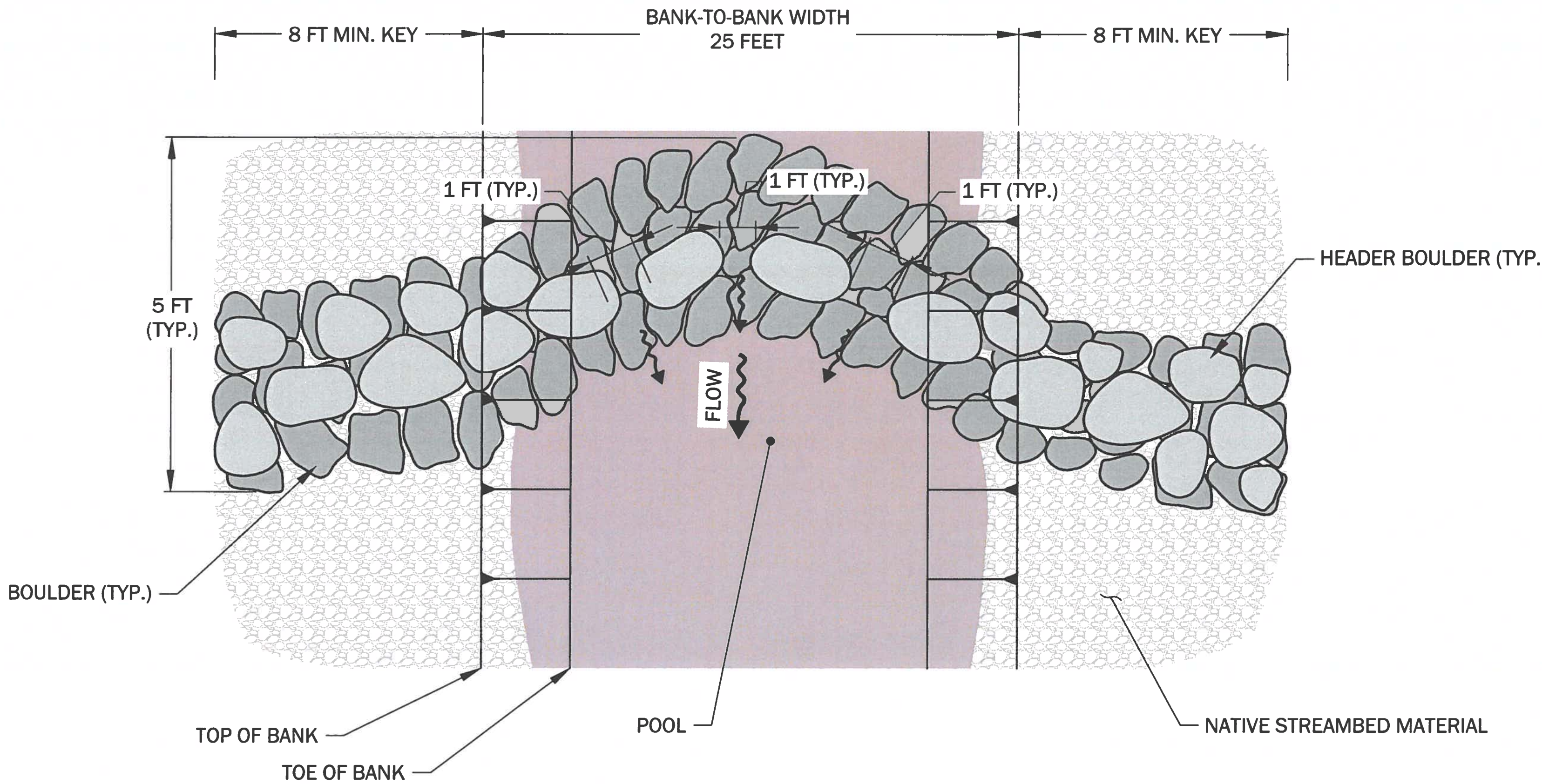
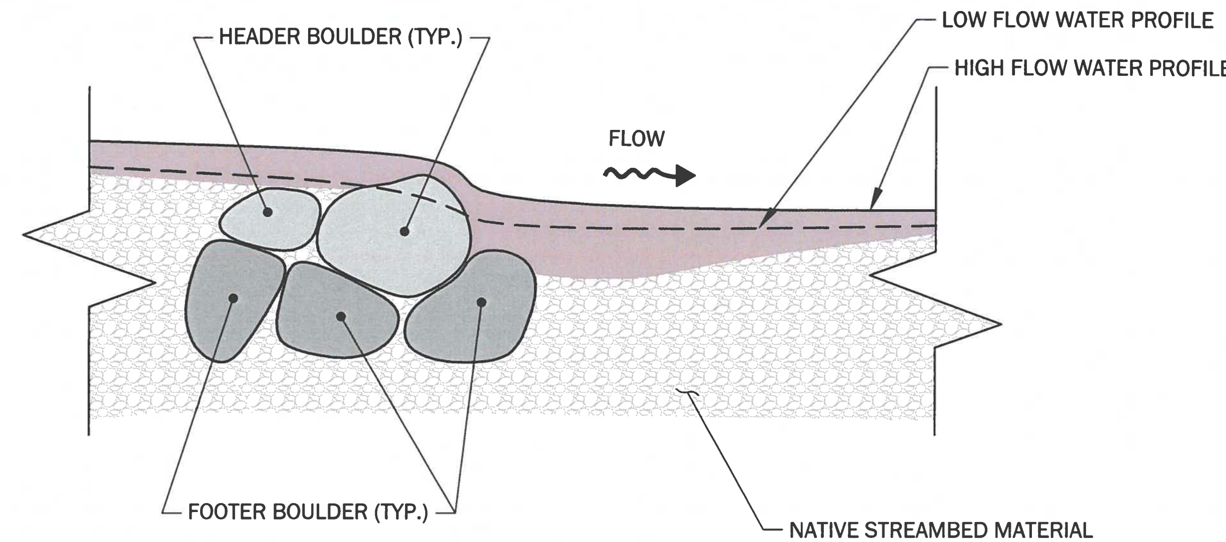


POROUS ROCK WEIR AND POOL SEQUENCE PLAN VIEW

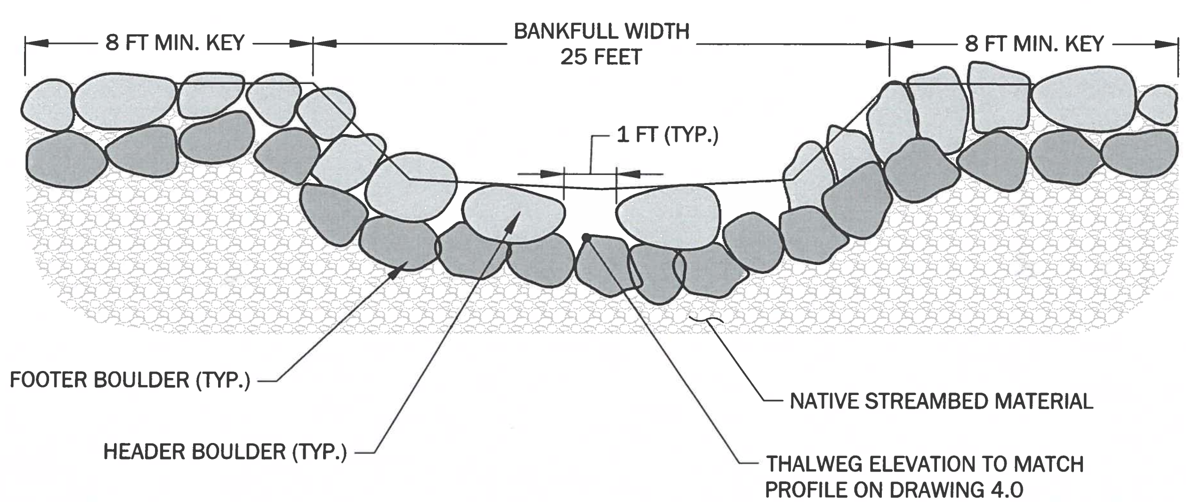


POROUS ROCK WEIR AND POOL SEQUENCE PROFILE VIEW

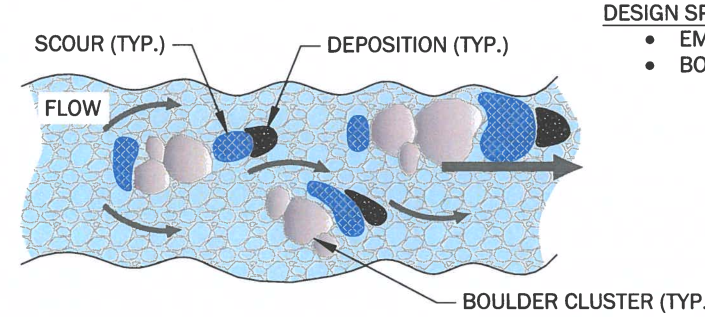
POROUS ROCK WEIR DESIGN SPECIFICATIONS:
OVERALL MATERIAL GRADATION IS APPROXIMATELY:

- 20 PERCENT 12 IN - 18 IN BOULDERS
- 30 PERCENT 18 IN - 28 IN BOULDERS
- 50 PERCENT 28 IN - 36 IN BOULDERS

HEADER BOULDERS SHALL BE BETWEEN 28 IN - 36 IN



POROUS ROCK WEIR AND POOL SEQUENCE SECTION VIEW



BOULDER CLUSTER DETAIL

DESIGN SPECIFICS:

- EMBED BOULDERS 2/3 IN CHANNEL BED
- BOULDER DIAMETER 28 IN TO 36 IN.

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9/29/21

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ROCK WEIR DETAILS

DRAWING NUMBER: 5.3
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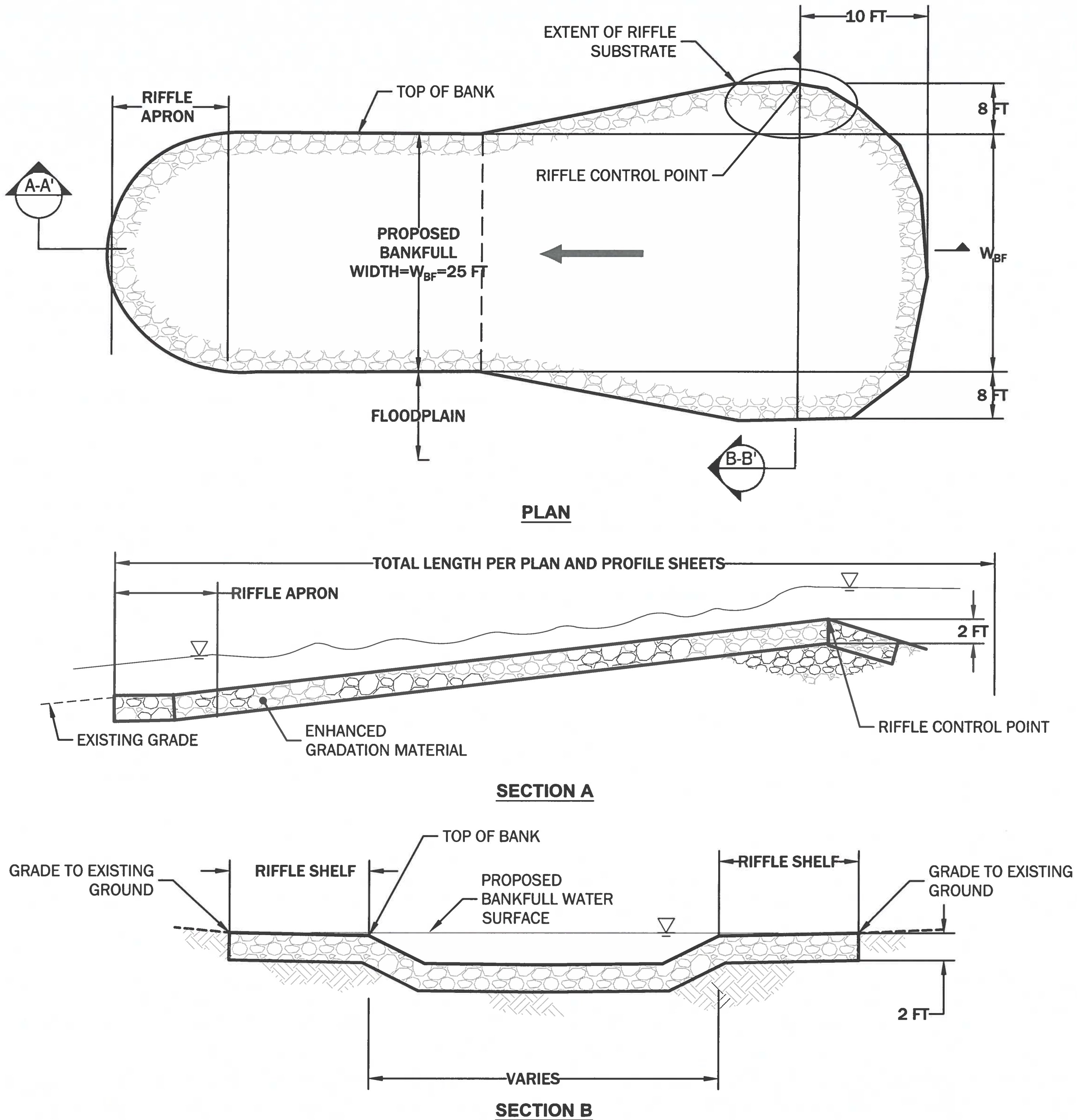

TYPICAL CONSTRUCTED RIFFLE DETAIL

PROPOSED RIFFLE ENHANCED GRADATION	
D16 (IN)	1.3
D50 (IN)	4.2
D84 (IN)	8.0
D100 (IN)	12.0

CONSTRUCTED RIFFLE GRADATION VOLUMES		
STATION RANGE	RIFFLE LENGTH (FT)	VOLUME OF PLACE MATERIAL (CY)
8+12 TO 8+87	75	115
8+25 TO 10+00	75	115

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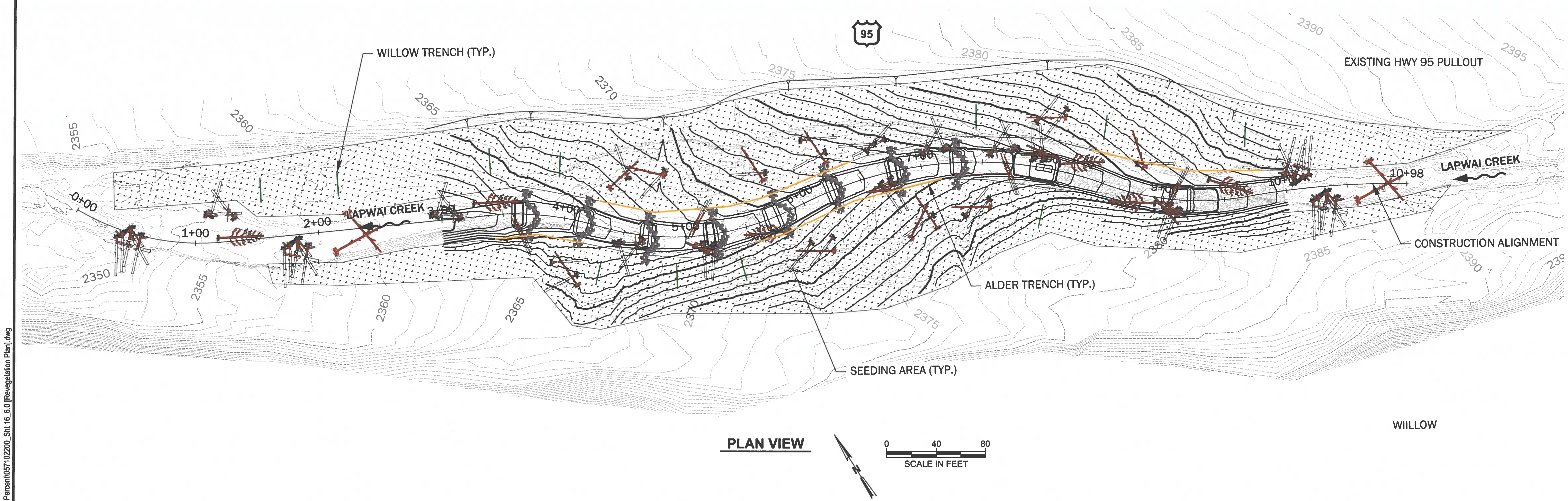
LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

RIFFLE DETAILS

DRAWING NUMBER: 5.4
SHEET: 15 OF 20

FINAL DESIGN



PLAN VIEW

PROFESSIONAL ENGINEER
LICENSED
11547
STATE OF IDAHO
RYAN S. CARNIE
9/29/21

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LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

REVEGETATION PLAN

DRAWING NUMBER:
6.0
SHEET: 16 OF 20

FINAL DESIGN

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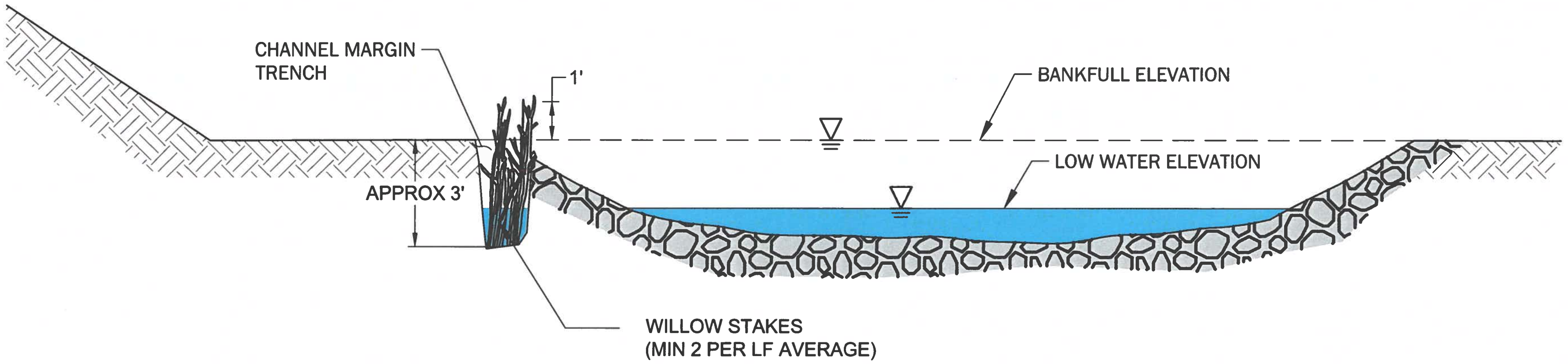
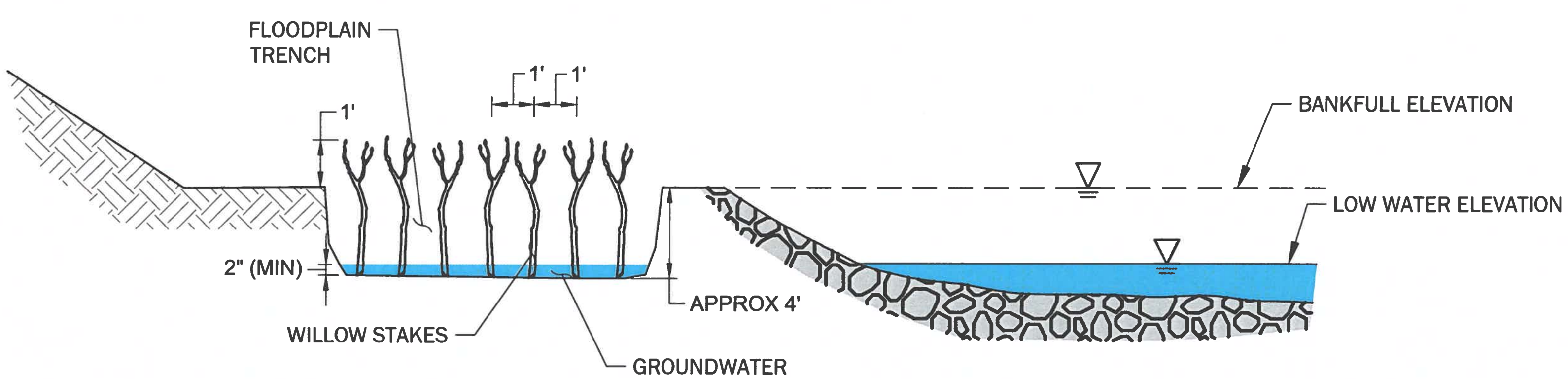


CHANNEL MARGIN WILLOW/ALDER TRENCH DETAIL

NOT TO SCALE



FLOODPLAIN WILLOW TRENCH DETAIL

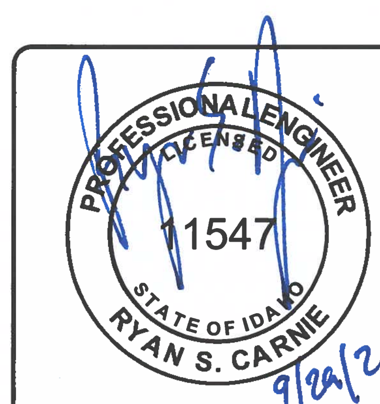
NOT TO SCALE

SEED MIX INCLUDES APPROXIMATELY 2.3 ACRES			
SPECIES	SIZE	LBS/ACRE	QUANTITY (LBS)
ANNUAL RYEGRASS	SEED	10	23
IDAHO FESCUE	SEED	3	6.9
BLUE WILDRYE	SEED	10	23
MOUNTAIN BROME	SEED	12	27.6

NOTES

1. THE SEED MIX IS SUGGESTED BASED ON PAST WORK BUT CAN BE SUBSTITUTED WITH SIMILAR MIX AS APPROVED BY THE NEZ PERCE TRIBE.
2. INSTALL CUTTINGS ABOVE THE 1.01-YEAR WATER SURFACE ELEVATION AND BELOW THE 2-YEAR WATER SURFACE ELVATION SO STEM INTERCEPT SHALLOW GROUNDWATER AT LOW-FLOW CONDITIONS.

WILLOW/ALDER TRENCH PLANTING					
SPECIES	TOTAL TRENCH LENGTH (FT)	STAKE SIZE		SPACING (FT.)	QUANTITY
		LENGTH (FT.) (MIN)	DIAMETER (INCH) (MIN/MAX)		
WILLOW (SALIX SP.)-FLOODPLAIN	240	4	0.5/1.5	1	240
ALDER (ALNUS RUBRA)-CHANNEL MARGIN	584	3	0.5/1.5	1	584



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LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

REVEGETATION DETAILS

DRAWING NUMBER: 6.1
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HIP GENERAL CONSERVATION MEASURES APPLICABLE TO ALL ACTIONS

THE ACTIVITIES COVERED UNDER THE HIP ARE INTENDED TO PROTECT AND RESTORE FISH AND WILDLIFE HABITAT WITH LONG-TERM BENEFITS TO ESA-LISTED SPECIES. THE FOLLOWING GENERAL CONSERVATION MEASURES (DEVELOPED IN COORDINATION WITH USFWS AND NMFS) WILL BE APPLIED TO ALL ACTIONS OF THIS PROJECT.

PROJECT DESIGN AND SITE PREPARATION.

1. STATE AND FEDERAL PERMITS.

A. ALL APPLICABLE REGULATORY PERMITS AND OFFICIAL PROJECT AUTHORIZATIONS WILL BE OBTAINED BEFORE PROJECT IMPLEMENTATION.

B. THESE PERMITS AND AUTHORIZATIONS INCLUDE, BUT ARE NOT LIMITED TO, NATIONAL ENVIRONMENTAL POLICY ACT, NATIONAL HISTORIC PRESERVATION ACT, THE APPROPRIATE STATE AGENCY REMOVAL AND FILL PERMIT, USACE CLEAN WATER ACT (CWA) 404 PERMITS, CWA SECTION 401 WATER QUALITY CERTIFICATIONS, AND FEMA NO-RISE ANALYSES.

2. TIMING OF IN-WATER WORK.

A. APPROPRIATE STATE (OREGON DEPARTMENT OF FISH AND WILDLIFE (ODFW), WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW), IDAHO DEPARTMENT OF FISH AND GAME (IDFG), AND MONTANA FISH WILDLIFE AND PARKS (MFWP)) GUIDELINES FOR TIMING OF IN-WATER WORK WINDOWS (IWW) WILL BE FOLLOWED.

B. CHANGES TO ESTABLISHED WORK WINDOWS WILL BE APPROVED BY REGIONAL STATE BIOLOGISTS AND BPA'S EC LEAD.

C. BULL TROUT. FOR AREAS WITH DESIGNATED IN-WATER WORK WINDOWS FOR BULL TROUT OR AREAS KNOWN TO HAVE BULL TROUT, PROJECT PROPONENTS WILL CONTACT THE APPROPRIATE USFWS FIELD OFFICE TO INSURE THAT ALL REASONABLE IMPLEMENTATION MEASURES ARE CONSIDERED AND AN APPROPRIATE IN-WATER WORK WINDOW IS BEING USED TO MINIMIZE PROJECT EFFECTS.

D. LAMPREY. WORKING IN STREAM OR RIVER CHANNELS THAT CONTAIN PACIFIC LAMPREY WILL BE AVOIDED FROM MARCH 1 TO JULY 1 FOR REACHES <5,000 FEET IN ELEVATION AND FROM MARCH 1 TO AUGUST 1 FOR REACHES >5,000 FEET. IF EITHER TIMEFRAME IS INCOMPATIBLE WITH OTHER OBJECTIVES, THE AREA WILL BE SURVEYED FOR NESTS AND LAMPREY PRESENCE, AND AVOIDED IF POSSIBLE. IF LAMPREYS ARE KNOWN TO EXIST, THE PROJECT SPONSOR WILL UTILIZE DEWATERING AND SALVAGE PROCEDURES (SEE FISH SALVAGE AND ELECTROFISHING SECTIONS) TO MINIMIZE ADVERSE EFFECTS.

E. THE IN-WATER WORK WINDOW WILL BE PROVIDED IN THE CONSTRUCTION PLANS.

3. CONTAMINANTS.

A. EXCAVATION OF MORE THAN 20 CUBIC YARDS WILL REQUIRE A SITE VISIT AND DOCUMENTED ASSESSMENT FOR POTENTIAL CONTAMINANT SOURCES. THE SITE ASSESSMENT WILL BE STORED WITH PROJECT FILES OR AS AN APPENDIX TO THE BASIS OF DESIGN REPORT.

B. THE SITE ASSESSMENT WILL SUMMARIZE:

1. THE SITE VISIT, CONDITION OF THE PROPERTY, AND IDENTIFICATION OF ANY AREAS USED FOR VARIOUS INDUSTRIAL PROCESSES;
2. AVAILABLE RECORDS, SUCH AS FORMER SITE USE, BUILDING PLANS, AND RECORDS OF ANY PRIOR CONTAMINATION EVENTS;
3. INTERVIEWS WITH KNOWLEDGEABLE PEOPLE, SUCH AS SITE OWNERS, OPERATORS, OCCUPANTS, NEIGHBORS, OR LOCAL GOVERNMENT OFFICIALS; AND
4. THE TYPE, QUANTITY, AND EXTENT OF ANY POTENTIAL CONTAMINATION SOURCES.

4. SITE LAYOUT AND FLAGGING.

A. CONSTRUCTION AREAS TO BE CLEARLY FLAGGED PRIOR TO CONSTRUCTION.

B. AREAS TO BE FLAGGED WILL INCLUDE:

1. SENSITIVE RESOURCE AREAS, SUCH AS AREAS BELOW ORDINARY HIGH WATER, SPAWNING AREAS, SPRINGS, AND WETLANDS;
2. EQUIPMENT ENTRY AND EXIT POINTS;
3. ROAD AND STREAM CROSSING ALIGNMENTS;
4. STAGING, STORAGE, AND STOCKPILE AREAS; AND
5. NO-SPRAY AREAS AND BUFFERS.

5. TEMPORARY ACCESS ROADS AND PATHS.

A. EXISTING ACCESS ROADS AND PATHS WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER AND LENGTH OF TEMPORARY ACCESS ROADS AND PATHS THROUGH RIPARIAN AREAS AND FLOODPLAINS WILL BE MINIMIZED.

B. VEHICLE USE AND HUMAN ACTIVITIES, INCLUDING WALKING, IN AREAS OCCUPIED BY TERRESTRIAL ESA-LISTED SPECIES WILL BE MINIMIZED.

C. TEMPORARY ACCESS ROADS AND PATHS WILL NOT BE BUILT ON SLOPES WHERE GRADE, SOIL, OR OTHER FEATURES SUGGEST A LIKELIHOOD OF EXCESSIVE EROSION OR FAILURE. IF SLOPES ARE STEEPER THAN 30%, THEN THE ROAD WILL BE DESIGNED BY A CIVIL ENGINEER WITH EXPERIENCE IN STEEP ROAD DESIGN.

D. THE REMOVAL OF RIPARIAN VEGETATION DURING CONSTRUCTION OF TEMPORARY ACCESS ROADS WILL BE MINIMIZED. WHEN TEMPORARY VEGETATION REMOVAL IS REQUIRED, VEGETATION WILL BE CUT AT GROUND LEVEL (NOT GRUBBED).

E. AT PROJECT COMPLETION, ALL TEMPORARY ACCESS ROADS AND PATHS WILL BE OBLITERATED, AND THE SOIL WILL BE STABILIZED AND REVEGETATED. ROAD AND PATH OBLITERATION REFERS TO THE MOST COMPREHENSIVE DEGREE OF DECOMMISSIONING AND INVOLVES DECOMPACTING THE SURFACE AND DITCH, PULLING THE FILL MATERIAL ONTO THE RUNNING SURFACE, AND RESHAPING TO MATCH THE ORIGINAL CONTOUR.

F. HELICOPTER FLIGHT PATTERNS WILL BE ESTABLISHED IN ADVANCE AND LOCATED TO AVOID TERRESTRIAL ESA-LISTED SPECIES AND THEIR OCCUPIED HABITAT DURING SENSITIVE LIFE STAGES.

6. TEMPORARY STREAM CROSSINGS.

A. EXISTING STREAM CROSSINGS OR BEDROCK WILL BE PREFERENTIALLY USED WHENEVER REASONABLE, AND THE NUMBER OF TEMPORARY STREAM CROSSINGS WILL BE MINIMIZED.

B. TEMPORARY BRIDGES AND CULVERTS WILL BE INSTALLED TO ALLOW FOR EQUIPMENT AND VEHICLE CROSSING OVER PERENNIAL STREAMS DURING CONSTRUCTION. TREATED WOOD SHALL NOT BE USED ON TEMPORARY BRIDGE CROSSINGS OR IN LOCATIONS IN CONTACT WITH OR DIRECTLY OVER WATER.

C. FOR PROJECTS THAT REQUIRE EQUIPMENT AND VEHICLES TO CROSS IN THE WET:

5. THE LOCATION AND NUMBER OF ALL WET CROSSINGS SHALL BE APPROVED BY THE BPA EC LEAD AND DOCUMENTED IN THE CONSTRUCTION PLANS;
6. VEHICLES AND MACHINERY SHALL CROSS STREAMS AT RIGHT ANGLES TO THE MAIN CHANNEL WHENEVER POSSIBLE;
7. NO STREAM CROSSINGS WILL OCCUR 300 FEET UPSTREAM OR 100 FEET DOWNSTREAM OF AN EXISTING REDD OR SPAWNING FISH; AND
8. AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE OBLITERATED AND BANKS RESTORED.

7. STAGING, STORAGE, AND STOCKPILE AREAS.

A. STAGING AREAS (USED FOR CONSTRUCTION EQUIPMENT STORAGE, VEHICLE STORAGE, FUELING, SERVICING, AND HAZARDOUS MATERIAL STORAGE) WILL BE 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND. STAGING AREAS CLOSER THAN 150 FEET WILL BE APPROVED BY THE EC LEAD.

B. NATURAL MATERIALS USED FOR IMPLEMENTATION OF AQUATIC RESTORATION, SUCH AS LARGE WOOD, GRAVEL, AND BOULDERS, MAY BE STAGED WITHIN 150 FEET IF CLEARLY INDICATED IN THE PLANS THAT AREA IS FOR NATURAL MATERIALS ONLY.

C. ANY LARGE WOOD, TOPSOIL, AND NATIVE CHANNEL MATERIAL DISPLACED BY CONSTRUCTION WILL BE STOCKPILED FOR USE DURING SITE RESTORATION AT A SPECIFICALLY IDENTIFIED AND FLAGGED AREA.

D. ANY MATERIAL NOT USED IN RESTORATION, AND NOT NATIVE TO THE FLOODPLAIN, WILL BE DISPOSED OF OUTSIDE THE 100-YEAR FLOODPLAIN.

8. EQUIPMENT.

A. MECHANIZED EQUIPMENT AND VEHICLES WILL BE SELECTED, OPERATED, AND MAINTAINED IN A MANNER THAT MINIMIZES ADVERSE EFFECTS ON THE ENVIRONMENT (E.G., MINIMALLY-SIZED, LOW PRESSURE TIRES; MINIMAL HARD-TURN PATHS FOR TRACKED VEHICLES; TEMPORARY MATS OR PLATES WITHIN WET AREAS OR ON SENSITIVE SOILS).

B. EQUIPMENT WILL BE STORED, FUELED, AND MAINTAINED IN AN CLEARLY IDENTIFIED STAGING AREA THAT MEETS STAGING AREA CONSERVATION MEASURES.

C. EQUIPMENT WILL BE REFUELED IN A VEHICLE STAGING AREA OR IN AN ISOLATED HARD ZONE, SUCH AS A PAVED PARKING LOT OR ADJACENT, ESTABLISHED ROAD (THIS MEASURE APPLIES ONLY TO GAS-POWERED EQUIPMENT WITH TANKS LARGER THAN 5 GALLONS).

D. BIODEGRADABLE LUBRICANTS AND FLUIDS WILL BE USED ON EQUIPMENT OPERATING IN AND ADJACENT TO THE STREAM CHANNEL AND LIVE WATER.

E. EQUIPMENT WILL BE INSPECTED DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION WITHIN 150 FEET OF ANY NATURAL WATER BODY OR WETLAND.

F. EQUIPMENT WILL BE THOROUGHLY CLEANED BEFORE OPERATION BELOW ORDINARY HIGH WATER, AND AS OFTEN AS NECESSARY DURING OPERATION, TO REMAIN GREASE FREE.

9. EROSION CONTROL.

A. TEMPORARY EROSION CONTROL MEASURES INCLUDE:

1. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND APPROPRIATELY INSTALLED DOWNSLOPE OF PROJECT ACTIVITY WITHIN THE RIPARIAN BUFFER AREA UNTIL SITE REHABILITATION IS COMPLETE;
2. IF THERE IS A POTENTIAL FOR ERODED SEDIMENT TO ENTER THE STREAM, SEDIMENT BARRIERS WILL BE INSTALLED AND MAINTAINED FOR THE DURATION OF PROJECT IMPLEMENTATION;
3. TEMPORARY EROSION CONTROL MEASURES MAY INCLUDE SEDGE MATS, FIBER WATTLES, SILT FENCES, JUTE MATTING, WOOD FIBER MULCH AND SOIL BINDER, OR GEOTEXTILES AND GEOSYNTHETIC FABRIC;
4. SOIL STABILIZATION UTILIZING WOOD FIBER MULCH AND TACKIFIER (HYDRO-APPLIED) MAY BE USED TO REDUCE EROSION OF BARE SOIL IF THE MATERIALS ARE NOXIOUS WEED FREE AND NONTOXIC TO AQUATIC AND TERRESTRIAL ANIMALS, SOIL MICROORGANISMS, AND VEGETATION;
5. SEDIMENT WILL BE REMOVED FROM EROSION CONTROLS ONCE IT HAS REACHED 1/3 OF THE EXPOSED HEIGHT OF THE CONTROL; AND
6. ONCE THE SITE IS STABILIZED AFTER CONSTRUCTION, TEMPORARY EROSION CONTROL MEASURES WILL BE REMOVED.

B. EMERGENCY EROSION CONTROLS. THE FOLLOWING MATERIALS FOR EMERGENCY EROSION CONTROL WILL BE AVAILABLE AT THE WORK SITE:

1. A SUPPLY OF SEDIMENT CONTROL MATERIALS; AND
2. AN OIL-ABSORBING FLOATING BOOM WHENEVER SURFACE WATER IS PRESENT.

10. DUST ABATEMENT.

A. THE PROJECT SPONSOR WILL DETERMINE THE APPROPRIATE DUST CONTROL MEASURES BY CONSIDERING SOIL TYPE, EQUIPMENT USAGE, PREVAILING WIND DIRECTION, AND THE EFFECTS CAUSED BY OTHER EROSION AND SEDIMENT CONTROL MEASURES.

B. WORK WILL BE SEQUENCED AND SCHEDULED TO REDUCE EXPOSED BARE SOIL SUBJECT TO WIND EROSION.

C. DUST-ABATEMENT ADDITIVES AND STABILIZATION CHEMICALS (TYPICALLY MAGNESIUM CHLORIDE, CALCIUM CHLORIDE SALTS, OR LIGNINSULFONATE) WILL NOT BE APPLIED WITHIN 25 FEET OF WATER OR A STREAM CHANNEL AND WILL BE APPLIED SO AS TO MINIMIZE THE LIKELIHOOD THAT THEY WILL ENTER STREAMS. APPLICATIONS OF LIGNINSULFONATE WILL BE LIMITED TO A MAXIMUM RATE OF 0.5 GALLONS PER SQUARE YARD OF ROAD SURFACE, ASSUMING MIXED 50:50 WITH WATER.

PROFESSIONAL ENGINEER LICENSED 11547 STATE OF IDAHO RYAN S. CARNIE 9/29/21

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APPROVED BY:	RSC
REVISION NO.:	—
DATE:	09/30/2021

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PREPARED FOR: NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

HIP IV GENERAL CONSERVATION MEASURES

DRAWING NUMBER: 7.0

SHEET: 18 OF 20

FINAL DESIGN

D. APPLICATION OF DUST ABATEMENT CHEMICALS WILL BE AVOIDED DURING OR JUST BEFORE WET WEATHER, AND AT STREAM CROSSINGS OR OTHER AREAS THAT COULD RESULT IN UNFILTERED DELIVERY OF THE DUST ABATEMENT MATERIALS TO A WATERBODY (TYPICALLY THESE WOULD BE AREAS WITHIN 25 FEET OF A WATERBODY OR STREAM CHANNEL; DISTANCES MAY BE GREATER WHERE VEGETATION IS SPARSE OR SLOPES ARE STEEP).

E. SPILL CONTAINMENT EQUIPMENT WILL BE AVAILABLE DURING APPLICATION OF DUST ABATEMENT CHEMICALS.

F. PETROLEUM-BASED PRODUCTS WILL NOT BE USED FOR DUST ABATEMENT.

11. SPILL PREVENTION, CONTROL, AND COUNTER MEASURES.

A. A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES WILL BE AVAILABLE ON-SITE.

B. WRITTEN PROCEDURES FOR NOTIFYING ENVIRONMENTAL RESPONSE AGENCIES WILL BE POSTED AT THE WORK SITE.

C. SPILL CONTAINMENT KITS (INCLUDING INSTRUCTIONS FOR CLEANUP AND DISPOSAL) ADEQUATE FOR THE TYPES AND QUANTITY OF HAZARDOUS MATERIALS USED AT THE SITE WILL BE AVAILABLE AT THE WORK SITE.

D. WORKERS WILL BE TRAINED IN SPILL CONTAINMENT PROCEDURES AND WILL BE INFORMED OF THE LOCATION OF SPILL CONTAINMENT KITS.

E. ANY WASTE LIQUIDS GENERATED AT THE STAGING AREAS WILL BE TEMPORARILY STORED UNDER AN IMPERVIOUS COVER, SUCH AS A TARPAULIN, UNTIL THEY CAN BE PROPERLY TRANSPORTED TO AND DISPOSED OF AT A FACILITY THAT IS APPROVED FOR RECEIPT OF HAZARDOUS MATERIALS.

F. PUMPS USED ADJACENT TO WATER SHALL USE SPILL CONTAINMENT SYSTEMS.

12. INVASIVE SPECIES CONTROL.

A. PRIOR TO ENTERING THE SITE, ALL VEHICLES AND EQUIPMENT WILL BE POWER WASHED, ALLOWED TO FULLY DRY, AND INSPECTED TO MAKE SURE NO PLANTS, SOIL, OR OTHER ORGANIC MATERIAL ADHERES TO THE SURFACE.

B. WATERCRAFT, WADERS, BOOTS, AND ANY OTHER GEAR TO BE USED IN OR NEAR WATER WILL BE INSPECTED FOR AQUATIC INVASIVE SPECIES.

C. WADING BOOTS WITH FELT SOLES ARE NOT TO BE USED DUE TO THEIR PROPENSITY FOR AIDING IN THE TRANSFER OF INVASIVE SPECIES UNLESS DECONTAMINATION PROCEDURES HAVE BEEN APPROVED BY THE EC LEAD.

WORK AREA ISOLATION AND FISH SALVAGE.

1. WORK AREA ISOLATION.

A. ANY WORK AREA WITHIN THE WETTED CHANNEL WILL BE ISOLATED FROM THE ACTIVE STREAM WHENEVER ESA-LISTED FISH ARE REASONABLY CERTAIN TO BE PRESENT, OR IF THE WORK AREA IS LESS THAN 300-FEET UPSTREAM FROM KNOWN SPAWNING HABITATS.

B. WORK AREA ISOLATION AND FISH SALVAGE ACTIVITIES WILL COMPLY WITH THE IN-WATER WORK WINDOW.

C. DESIGN PLANS WILL INCLUDE ALL ISOLATION ELEMENTS AND AREAS (COFFER DAMS, PUMPS, DISCHARGE AREAS, FISH SCREENS, FISH RELEASE AREAS, ETC.).

D. WORK AREA ISOLATION AND FISH CAPTURE ACTIVITIES WILL OCCUR DURING PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES POSSIBLE, NORMALLY EARLY IN THE MORNING VERSUS LATE IN THE DAY, AND DURING CONDITIONS APPROPRIATE TO MINIMIZE STRESS AND DEATH OF SPECIES PRESENT.

2. FISH SALVAGE.

A. MONITORING AND RECORDING WILL TAKE PLACE FOR DURATION OF SALVAGE. THE SALVAGE REPORT WILL BE COMMUNICATED TO AGENCIES VIA THE PROJECT COMPLETION FORM (PCF).

B. SALVAGE ACTIVITIES SHOULD TAKE PLACE DURING CONDITIONS TO MINIMIZE STRESS TO FISH SPECIES, TYPICALLY PERIODS OF THE COOLEST AIR AND WATER TEMPERATURES WHICH OCCUR IN THE MORNING VERSUS LATE IN THE DAY.

C. SALVAGE OPERATIONS WILL FOLLOW THE ORDERING, METHODS, AND CONSERVATION MEASURES SPECIFIED BELOW:

1. SLOWLY REDUCE WATER FROM THE WORK AREA TO ALLOW SOME FISH TO LEAVE VOLITIONALLY.
2. BLOCK NETS WILL BE INSTALLED AT UPSTREAM AND DOWNSTREAM LOCATIONS AND MAINTAINED IN A SECURED POSITION TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.
3. BLOCK NETS WILL BE SECURED TO THE STREAM CHANNEL BED AND BANKS UNTIL FISH CAPTURE AND TRANSPORT ACTIVITIES ARE COMPLETE. BLOCK NETS MAY BE LEFT IN PLACE FOR THE DURATION OF THE PROJECT TO EXCLUDE FISH AS LONG AS PASSAGE REQUIREMENTS ARE MET.
4. NETS WILL BE MONITORED HOURLY DURING IN-STREAM DISTURBANCE.
5. IF BLOCK NETS REMAIN IN PLACE MORE THAN ONE DAY, THE NETS WILL BE MONITORED AT LEAST DAILY TO ENSURE THEY ARE SECURED AND FREE OF ORGANIC ACCUMULATION. IF BULL TROUT ARE PRESENT, NETS ARE TO BE CHECKED EVERY 4 HOURS FOR FISH IMPINGEMENT.
6. CAPTURE FISH THROUGH SEINING AND RELOCATE TO STREAMS.
7. WHILE DEWATERING, ANY REMAINING FISH WILL BE COLLECTED BY HAND OR DIP NETS.
8. SEINES WITH A MESH SIZE TO ENSURE CAPTURE OF THE RESIDING ESA-LISTED FISH WILL BE USED.
9. MINNOW TRAPS WILL BE LEFT IN PLACE OVERNIGHT AND USED IN CONJUNCTION WITH SEINING.
10. ELECTROFISH TO CAPTURE AND RELOCATED FISH NOT CAUGHT DURING SEINING PER ELECTROFISH CONSERVATION MEASURES.
11. CONTINUE TO SLOWLY DEWATER STREAM REACH.
12. COLLECT ANY REMAINING FISH IN COLD-WATER BUCKETS AND RELOCATED TO THE STREAM.
13. LIMIT THE TIME FISH ARE IN A TRANSPORT BUCKET.
14. MINIMIZE PREDATION BY TRANSPORTING COMPARABLE SIZES IN BUCKETS.
15. BUCKET WATER TO BE CHANGED EVERY 15 MINUTES OR AERATED.
16. BUCKETS WILL BE KEPT IN SHADED AREAS OR COVERED.
17. DEAD FISH WILL NOT BE STORED IN TRANSPORT BUCKETS, BUT WILL BE LEFT ON THE STREAM BANK TO AVOID MORTALITY COUNTING ERRORS.

D. SALVAGE GUIDELINES FOR BULL TROUT, LAMPREY, MUSSELS, AND NATIVE FISH.

1. CONDUCT SITE SURVEY TO ESTIMATE SALVAGE NUMBERS.
2. PRE-SELECT SITE(S) FOR RELEASE AND/OR MUSSEL BED RELOCATION.
3. SALVAGE OF BULL TROUT WILL NOT TAKE PLACE WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.
4. IF DRAWDOWN LESS THAN 48 HOURS, SALVAGE OF LAMPREY AND MUSSELS MAY NOT BE NECESSARY IF TEMPERATURES SUPPORT SURVIVAL IN SEDIMENTS.
5. SALVAGE MUSSELS BY HAND, LOCATING BY SNORKELING OR WADING.
6. SALVAGE LAMPREY BY ELECTROFISHING (SEE ELECTROFISHING FOR LARVAL LAMPREY SETTINGS AND LARVAL LAMPREY DRY SHOCKING SETTINGS).
7. SALVAGE BONY FISH AFTER LAMPREY WITH NETS OR ELECTROFISHING (SEE ELECTROFISHING FOR APPROPRIATE SETTINGS).
8. REGULARLY INSPECT DEWATERED SITE SINCE LAMPREY LIKELY TO EMERGE AFTER DEWATERING AND MUSSELS MAY BECOME VISIBLE.
9. MUSSELS MAY BE TRANSFERRED IN COOLERS.
10. MUSSELS WILL BE PLACED INDIVIDUALLY TO ENSURE ABILITY TO BURROW INTO NEW HABITAT.

3. ELECTROFISHING.

A. INITIAL SITE SURVEY AND INITIAL SETTINGS.

1. IDENTIFY SPAWNING ADULTS AND ACTIVE REDDS TO AVOID.
2. RECORD WATER TEMPERATURE. ELECTROFISHING WILL NOT OCCUR WHEN WATER TEMPERATURES ARE ABOVE 18 DEGREES CELSIUS.
3. IF POSSIBLE, A BLOCK NET WILL BE PLACED DOWNSTREAM AND CHECKED REGULARLY TO CAPTURE STUNNED FISH THAT DRIFT DOWNSTREAM.
4. INITIAL SETTINGS WILL BE 100 VOLTS, PULSE WIDTH OF 500 MICRO SECONDS, AND PULSE RATE OF 30 HERTZ.
5. RECORDS FOR CONDUCTIVITY, WATER TEMPERATURE, AIR TEMPERATURE, ELECTROFISHING SETTINGS, ELECTROFISHER MODEL, ELECTROFISHER CALIBRATION, FISH CONDITIONS, FISH MORTALITIES, AND TOTAL CAPTURE RATES WILL BE INCLUDED IN THE SALVAGE LOG BOOK.

B. ELECTROFISHING TECHNIQUE.

1. SAMPLING SHOULD BEGIN USING STRAIGHT DC. POWER WILL REMAIN ON UNTIL THE FISH IS NETTED WHEN USING STRAIGHT DC. GRADUALLY INCREASE VOLTAGE WHILE REMAINING BELOW MAXIMUM LEVELS.
2. MAXIMUM VOLTAGE WILL BE 1100 VOLTS WHEN CONDUCTIVITY IS <100 MILLISECONDS, 800 VOLTS WHEN CONDUCTIVITY IS BETWEEN 100 AND 300 MILLISECONDS, AND 400 VOLTS WHEN CONDUCTIVITY IS >300 MILLISECONDS.
3. IF FISH CAPTURE IS NOT SUCCESSFUL USING STRAIGHT DC, THE ELECTROFISHER WILL BE SET TO INITIAL VOLTAGE FOR PDC. VOLTAGE, PULSE WIDTH, AND PULSE FREQUENCY WILL BE GRADUALLY INCREASED WITHIN MAXIMUM VALUES UNTIL CAPTURE IS SUCCESSFUL.
4. MAXIMUM PULSE WIDTH IS 5 MILLISECONDS. MAXIMUM PULSE RATE IS 70 HERTZ
5. ELECTROFISHING WILL NOT OCCUR IN ONE AREA FOR AN EXTENDED PERIOD.
6. THE ANODE WILL NOT INTENTIONALLY COME INTO CONTACT WITH FISH. THE ZONE FOR POTENTIAL INJURY OF 0.5 M FROM THE ANODE WILL BE AVOIDED.
7. SETTINGS WILL BE LOWERED IN SHALLOWER WATER SINCE VOLTAGE GRADIENTS LIKELY TO INCREASE.
8. ELECTROFISHING WILL NOT OCCUR IN TURBID WATER WHERE VISIBILITY IS POOR (I.E. UNABLE TO SEE THE BED OF THE STREAM).
9. OPERATIONS WILL IMMEDIATELY STOP IF MORTALITY OR OBVIOUS FISH INJURY IS OBSERVED. ELECTROFISHING SETTINGS WILL BE REEVALUATED.

C. SAMPLE PROCESSING.

1. FISH SHALL BE SORTED BY SIZE TO AVOID PREDATION DURING CONTAINMENT.
2. SAMPLERS WILL REGULARLY CHECK CONDITIONS OF FISH HOLDING CONTAINERS, AIR PUMPS, WATER TRANSFERS, ETC.
3. FISH WILL BE OBSERVED FOR GENERAL CONDITIONS AND INJURIES
4. EACH FISH WILL BE COMPLETELY REVIVED BEFORE RELEASE. ESA-LISTED SPECIES WILL BE PRIORITIZED FOR SUCCESSFUL RELEASE.

D. BULL TROUT ELECTROFISHING.

1. ELECTROFISHING FOR BULL TROUT WILL ONLY OCCUR FROM MAY 1 TO JULY 31. NO ELECTROFISHING WILL OCCUR IN ANY BULL TROUT OCCUPIED HABITAT AFTER AUGUST 15. IN FMO HABITATS ELECTROFISHING MAY OCCUR ANY TIME.
2. ELECTROFISHING OF BULL TROUT WILL NOT OCCUR WHEN WATER TEMPERATURES EXCEED 15 DEGREES CELSIUS.

PROFESSIONAL ENGINEER LICENSED 11547 STATE OF IDAHO RYAN S. CARNIE 9/24/21

NO.	DATE	BY	ISSUE / DESCRIPTION

DESIGNED BY: AKM
DRAWN BY: AKM/SCY
APPROVED BY: RSC
REVISION NO.: —
DATE: 09/30/2021

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PREPARED FOR: NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

HIP IV GENERAL CONSERVATION MEASURES

DRAWING NUMBER: 7.1
SHEET: 19 OF 20

FINAL DESIGN

E. LARVAL LAMPREY ELECTROFISHING.

1. PERMISSION FROM EC LEAD WILL BE OBTAINED IF LARVAL LAMPREY ELECTROFISHER IS NOT ONE OF FOLLOWING PRE-APPROVED MODELS: ABP-2 "WISCONSIN", SMITH-ROOT LR-24, OR SMITH-ROOT APEX BACKPACK.
2. LARVAL LAMPREY SAMPLING WILL INCORPORATE 2-STAGE METHOD: "TICKLE" AND "STUN".
3. FIRST STAGE: USE 125 VOLT DC WITH A 25 PERCENT DUTY CYCLE APPLIED AT A SLOW RATE OF 3 PULSES PER SECOND. IF TEMPERATURES ARE BELOW 10 DEGREES CELSIUS, VOLTAGE MAY BE INCREASED GRADUALLY (NOT TO EXCEED 200 VOLTS). BURSTED PULSES (THREE SLOW AND ONE SKIPPED) RECOMMENDED TO INCREASE EMERGENCE.
4. SECOND STAGE (OPTIONAL FOR EXPERIENCED NETTERS): IMMEDIATELY AFTER LAMPREY EMERGE, USE A FAST PULSE SETTING OF 30 PULSES PER SECOND.
5. USE DIP NETS FOR VISIBLE LAMPREY. SIENES AND FINE MESH NET SWEEPS MAY BE USED IN POOR VISIBILITY.
6. SAMPLING WILL OCCUR SLOWLY (>60 SECONDS PER METER) STARTING AT UPSTREAM AND WORKING DOWNSTREAM.
7. MULTIPLE SWEEPS TO OCCUR WITH 15 MINUTES BETWEEN SWEEPS.
8. POST-DRAWDOWN "DRY-SHOCKING" WILL BE APPLIED IF LARVAL LAMPREY CONTINUE TO EMERGE. ANODES TO BE PLACED ONE METER APART TO SAMPLE ONE SQUARE METER AT A TIME FOR AT LEAST 60 SECONDS. FOR TEMPERATURES LESS THAN 10 DEGREES CELSIUS, MAXIMUM VOLTAGE MAY BE GRADUALLY INCREASED TO 400 VOLTS (DRY-SHOCKING ONLY).

4. DEWATERING.

A. DEWATERING WILL OCCUR AT A RATE SLOW ENOUGH TO ALLOW SPECIES TO NATURALLY MIGRATE OUT OF THE WORK AREA.

B. WHERE A GRAVITY FEED DIVERSION IS NOT POSSIBLE, A PUMP MAY BE USED. PUMPS WILL BE INSTALLED TO AVOID REPETIVE DEWATERING AND REWATERING.

C. WHEN FISH ARE PRESENT, PUMPS WILL BE SCREENED IN ACCORDANCE WITH NMFS FISH SCREEN CRITERIA. NMFS ENGINEERING REVIEW AND APPROVAL WILL BE OBTAINED FOR PUMPS EXCEEDING 3 CUBIC FEET PER SECOND.

D. DISSIPATION OF FLOW ENERGY AT THE BYPASS OUTFLOW WILL BE PROVIDED TO PREVENT DAMAGE TO THE STREAM CHANNEL AND RIPARIAN VEGETATION.

E. SEEPAGE WATER WILL BE PUMPED TO A TEMPORARY STORAGE AND TREATMENT SITE OF INTO UPLAND AREAS TO ALLOW WATER TO PERCOLATE THROUGH SOIL AND VEGETATION PRIOR TO REENTERING THE STREAM CHANNEL.

CONSTRUCTION AND POST CONSTRUCTION CONSERVATION MEASURES.

1. FISH PASSAGE.

A. FISH PASSAGE WILL BE PROVIDED FOR ADULT AND JUVENILE FISH LIKELY TO BE PRESENT DURING CONSTRUCTION UNLESS PASSAGE DID NOT EXIST BEFORE CONSTRUCTION, THE STREAM IS NATURALLY IMPASSABLE, OR PASSAGE WILL NEGATIVELY IMPACT ESA-LISTED SPECIES OR THEIR HABITAT.

B. FISH PASSAGE ALTERNATIVES WILL BE APPROVED BY THE BPA EC LEAD UNDER ADVISEMENT BY THE NMFS HABITAT BIOLOGIST.

2. CONSTRUCTION AND DISCHARGE WATER.

A. SURFACE WATER MAY BE DIVERTED TO MEET CONSTRUCTION NEEDS ONLY IF DEVELOPED SOURCES ARE UNAVAILABLE OR INADEQUATE.

B. DIVERSIONS WILL NOT EXCEED 10% OF THE AVAILABLE FLOW.

C. CONSTRUCTION DISCHARGE WATER WILL BE COLLECTED AND TREATED TO REMOVE DEBRIS, NUTRIENTS, SEDIMENT, PETROLEUM HYDROCARBONS, METALS, AND OTHER POLLUTANTS.

3. TIME AND EXTENT OF DISTURBANCE.

A. EARTHWORK REQUIRING IN-STREAM MECHANIZED EQUIPMENT (INCLUDING DRILLING, EXCAVATION, DREDGING, FILLING, AND COMPACTING) WILL BE COMPLETED AS QUICKLY AS POSSIBLE.

B. MECHANIZED EQUIPMENT WILL WORK FROM TOP OF BANK UNLESS WORK FROM ANOTHER LOCATION WILL RESULT IN LESS HABITAT DISTURBANCE (TURBIDITY, VEGETATION DISTURBANCE, ETC.).

4. CESSATION OF WORK.

A. PROJECT OPERATIONS WILL CEASE WHEN HIGH FLOW CONDITIONS MAY RESULT IN INUNDATION OF THE PROJECT AREA (FLOOD EFFORTS TO DECREASE DAMAGES TO NATURAL RESOURCES PERMITTED).

B. WATER QUALITY LEVELS EXCEEDED. SEE CWA SECTION 401 WATER QUALITY CERTIFICATION AND TURBIDITY MEASURES.

5. SITE RESTORATION.

A. DISTURBED AREAS, STREAM BANKS, SOILS, AND VEGETATION WILL BE CLEANED UP AND RESTORED TO IMPROVED OR PRE-PROJECT CONDITIONS.

B. PROJECT-RELATED WASTE WILL BE REMOVED.

C. TEMPORARY ACCESS ROADS AND STAGING WILL BE DECOMPACTED AND RESTORED. SOILS WILL BE LOOSENED IF NEEDED FOR REVEGETATION OR WATER INFILTRATION.

D. THE PROJECT SPONSOR WILL RETAIN THE RIGHT OF REASONABLE ACCESS TO THE SITE TO MONITOR AND MAINTAIN THE SITE OVER THE LIFE OF THE PROJECT.

6. REVEGETATION.

A. PLANTING AND SEEDING WILL OCCUR PRIOR TO OR AT THE BEGINNING OF THE FIRST GROWING SEASON AFTER CONSTRUCTION.

B. A MIX OF NATIVE SPECIES (INVASIVE SPECIES NOT ALLOWED) APPROPRIATE TO THE SITE WILL BE USED TO REESTABLISH VEGETATION, PROVIDE SHADE, AND REDUCE EROSION. REESTABLISHED VEGETATION SHOULD BE AT LEAST 70% OF PRE-PROJECT CONDITIONS WITHIN THREE YEARS.

C. VEGETATION SUCH AS WILLOWS, SEDGES, OR RUSH MATS WILL BE SALVAGED FROM DISTURBED OR ABANDONED AREAS TO BE REPLANTED.

D. SHORT-TERM STABILIZATION MEASURE MAY INCLUDE THE USE OF NON-NATIVE STERILE SEED MIX (WHEN NATIVE NOT AVAILABLE), WEED-FREE CERTIFIED STRAW, OR OTHER SIMILAR TECHNIQUES.

E. SURFACE FERTILIZER WILL NOT BE APPLIED WITHIN 50 FEET OF ANY STREAM, WATE BODY, OR WETLAND.

F. FENCING WILL BE INSTALLED AS NECESSARY TO PREVENT ACCESS TO REVEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS.

G. INVASIVE PLANTS WILL BE REMOVED OR CONTROLLED UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED (TYPICALLY THREE YEARS POST-CONSTRUCTION).

7. SITE ACCESS AND IMPLEMENTATION MONITORING.

A. THE PROJECT SPONSOR WILL PROVIDE CONSTRUCTION MONITORING DURING IMPLEMENTATION TO ENSURE ALL CONSERVATION MEASURES ARE ADEQUATELY FOLLOWED, EFFECTS TO LISTED SPECIES ARE NOT GREATER THAN PREDICTED, AND INCIDENTAL TAKE LIMITATIONS ARE NOT EXCEEDED.

B. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL SUBMIT THE PROJECT COMPLETION FORM (PCF) WITHIN 30 DAYS OF PROJECT COMPLETION.

8. CWA SECTION 401 WATER QUALITY CERTIFICATION.

A. THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL COMPLETE AND RECORD WATER QUALITY OBSERVATIONS (SEE TURBIDITY MONITORING) TO ENSURE IN-WATER WORK IS NOT DEGRADING WATER QUALITY.

B. DURING CONSTRUCTION, WATER QUALITY PROVISIONS PROVIDED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY, WASHINGTON DEPARTMENT OF ECOLOGY, IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY WILL BE FOLLOWED.

STAGED REWATERING PLAN.

A. WHEN REINTRODUCING WATER TO DEWATERED AREAS AND NEWLY CONSTRUCTED CHANNELS, A STAGED REWATERING PLAN WILL BE APPLIED.

B. THE FOLLOWING WILL BE APPLIED TO ALL REWATERING EFFORTS. COMPLEX REWATERING EFFORTS MAY REQUIRE ADDITIONAL NOTES OR A DEDICATED SHEET IN THE CONSTRUCTION DETAILS.

1. TURBIDITY MONITORING PROTOCOL WILL BE APPLIED TO REWATERING EFFORTS.
2. PRE-WASH THE AREA BEFORE REWATERING. TURBID WASH WATER WILL BE DETAINED AND PUMPED TO THE FLOODPLAIN OR SEDIMENT CAPTURE AREAS RATHER THAN DISCHARGING TO FISH-BEARING STREAMS.
3. INSTALL SEINE NETS AT UPSTREAM END TO PREVENT FISH FROM MOVING DOWNSTREAM UNTIL 2/3 OF TOTAL FLOW IS RESTORED TO THE CHANNEL.
4. STARTING IN EARLY MORNING INTRODUCE 1/3 OF NEW CHANNEL FLOW OVER PERIOD OF 1-2 HOURS.
5. INTRODUCE SECOND THIRD OF FLOW OVER NEXT 1 TO 2 HOURS AND BEGIN FISH SALVAGE OF BYPASS CHANNEL IF FISH ARE PRESENT.
6. REMOVE UPSTREAM SEINE NETS ONCE 2/3 FLOW IN REWATERED CHANNEL AND DOWNSTREAM TURBIDITY IS WITHIN ACCEPTABLE RANGE (LESS THAN 40 NTU OR LESS THAN 10% BACKGROUND).
7. INTRODUCE FINAL THIRD OF FLOW ONCE FISH SALVAGE EFFORTS ARE COMPLETE AND DOWNSTREAM TURBIDITY VERIFIED TO BE WITHIN ACCEPTABLE RANGE.
8. INSTALL PLUG TO BLOCK FLOW INTO OLD CHANNEL OR BYPASS. REMOVE ANY REMAINING SEINE NETS.
9. IN LAMPREY SYSTEMS, LAMPREY SALVAGE AND DRY SHOCKING MAY BE NECESSARY.

TURBIDITY MONITORING.

A. RECORD THE READING, LOCATION, AND TIME FOR THE BACKGROUND READING APPROXIMATELY 100 FEET UPSTREAM OF THE PROJECT AREA USING A RECENTLY CALIBRATED TURBIDIMETER OR VIA VISUAL OBSERVATION (SEE THE HIP HANDBOOK TURBIDITY MONITORING SECTION FOR A VISUAL OBSERVATION KEY).

B. RECORD THE TURBIDITY READING, LOCATION, AND TIME AT THE MEASUREMENT COMPLIANCE LOCATION POINT.

1. 50 FEET DOWNSTREAM FOR STREAMS LESS THAN 30 FEET WIDE.
2. 100 FEET DOWNSTREAM FOR STREAMS BETWEEN 30 AND 100 FEET WIDE.
3. 200 FEET DOWNSTREAM FOR STREAMS GREATER THAN 100 FEET WIDE.
4. 300 FEET FROM THE DISCHARGE POINT OR NONPOINT SOURCE FOR LOCATIONS SUBJECT TO TIDAL OR COASTAL SCOUR.

C. TURBIDITY SHALL BE MEASURED (BACKGROUND LOCATION AND COMPLIANCE POINTS) EVERY 4 HOURS WHILE WORK IS BEING IMPLEMENTED.

D. IF THERE IS A VISIBLE DIFFERENCE BETWEEN A COMPLIANCE POINT AND THE BACKGROUND, THE EXCEEDANCE WILL BE NOTED IN THE PROJECT COMPLETION FORM (PCF). ADJUSTMENTS OR CORRECTIVE MEASURES WILL BE TAKEN IN ORDER TO REDUCE TURBIDITY.

E. IF EXCEEDANCES OCCUR FOR MORE THAN TWO CONSECUTIVE MONITORING INTERVALS (AFTER 8 HOURS), THE ACTIVITY WILL STOP UNTIL THE TURBIDITY LEVEL RETURNS TO BACKGROUND. THE BPA EC LEAD WILL BE NOTIFIED OF ALL EXCEEDANCES AND CORRECTIVE ACTIONS AT PROJECT COMPLETION.

F. IF TURBIDITY CONTROLS (COFFER DAMS, WADDLES, FENCING, ETC.) ARE DETERMINED INEFFECTIVE, CREWS WILL BE MOBILIZED TO MODIFY AS NECESSARY. OCCURRENCES WILL BE DOCUMENTED IN THE PROJECT COMPLETION FORM (PCF).

G. FINAL TURBIDITY READINGS, EXCEEDANCES, AND CONTROL FAILURES WILL BE SUBMITTED TO THE BPA EC LEAD USING THE PROJECT COMPLETION FORM (PCF).

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11547
STATE OF IDAHO
RYAN S. CARNIE
9/29/21

NO.	DATE	BY	ISSUE / DESCRIPTION

DESIGNED BY: AKM
DRAWN BY: AKM/SCY
APPROVED BY: RSC
REVISION NO.: —
DATE: 09/30/2021

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PREPARED FOR: NEZ PERCE TRIBE

LAPWAI CREEK REACH 14 FLOODPLAIN AND HABITAT RESTORATION
NEZ PERCE COUNTY, IDAHO

HIP IV GENERAL CONSERVATION MEASURES

DRAWING NUMBER: 7.2
SHEET: 20 OF 20

FINAL DESIGN

APPENDIX B
Site Photographs

Photograph 1. Existing channel incision along Lapwai Creek.

Photograph 2. Existing downcutting along Lapwai Creek.

Site Photographs

Lapwai Creek Reach 14
Nez Perce County, Idaho

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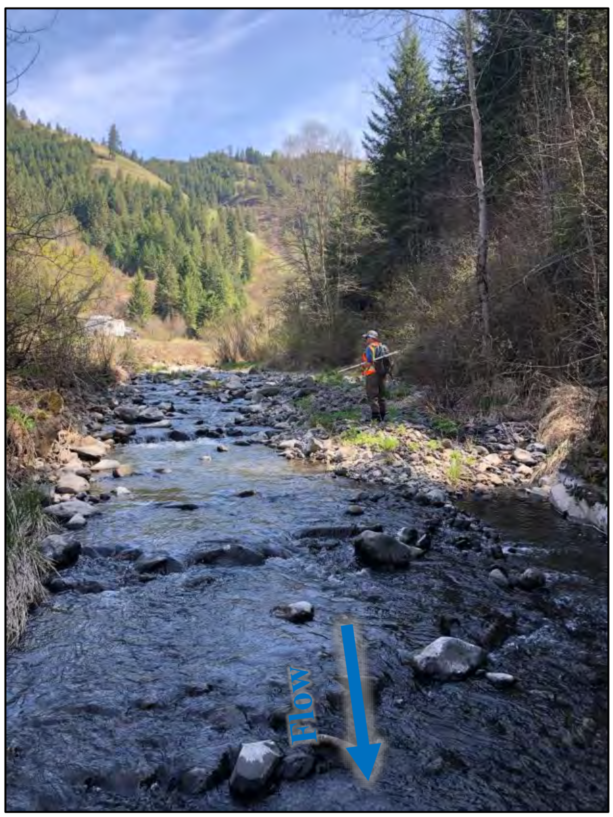
Figure B-1

Photograph 3. Existing conditions upstream of highway 95 pullout.



Photograph 4. Existing Lapwai Creek step-pool configuration, upstream of project reach.

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Site Photographs

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure B-2

Photograph 5. Bankfull width measurement downstream of project reach.

Photograph 6. Existing downcutting within Lapwai Creek. Previously constructed large woody material now perched.

Site Photographs

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure B-3

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Photograph 7. Disconnected Lapwai Creek channel.

Photograph 8. Existing Idaho Department of Transportation's culvert, upstream of project site.

Site Photographs

Lapwai Creek Reach 14
Nez Perce County, Idaho

GeoEngineers

Figure B-4

0571-022-00 Date Exported: 09/01/21

Photograph 9. Existing vegetation and large woody, downstream project reach.

Photograph 10. Existing mobile sediment gradation. Photograph taken downstream of project reach.

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Site Photographs

Lapwai Creek Reach 14
Nez Perce County, Idaho

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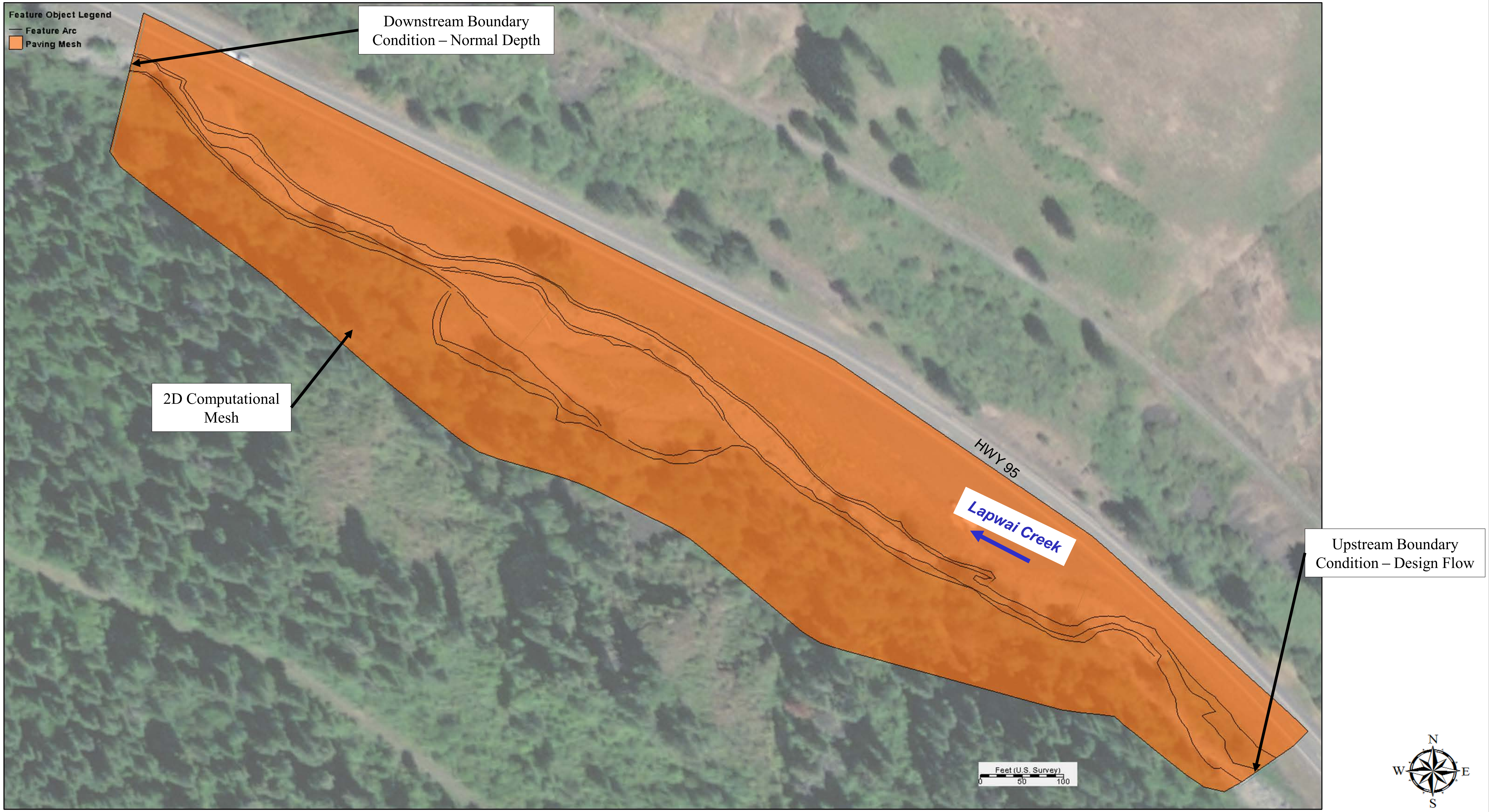
Figure B-5

Photograph 11. Overview of the proposed project area post construction (looking downstream). Photograph taken in December 2018 by NPT.

Photograph 12. Overview of the project area post flood events (looking downstream). Photograph taken on February 19, 2020 by NPT.

Site Photographs	
Lapwai Creek Reach 14 Nez Perce County, Idaho	
GEOENGINEERS	Figure B-6

APPENDIX C
Hydrologic and Hydraulic Analyses



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Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. Data Source: SMS Version 13.1
4. Horizontal Projection: ID State Plane, W Zone, NAD83, International Feet
5. Vertical Projection: NAVD88

Existing Conditions Mesh

Lapwai Creek Reach 14
Nez Perce County, Idaho

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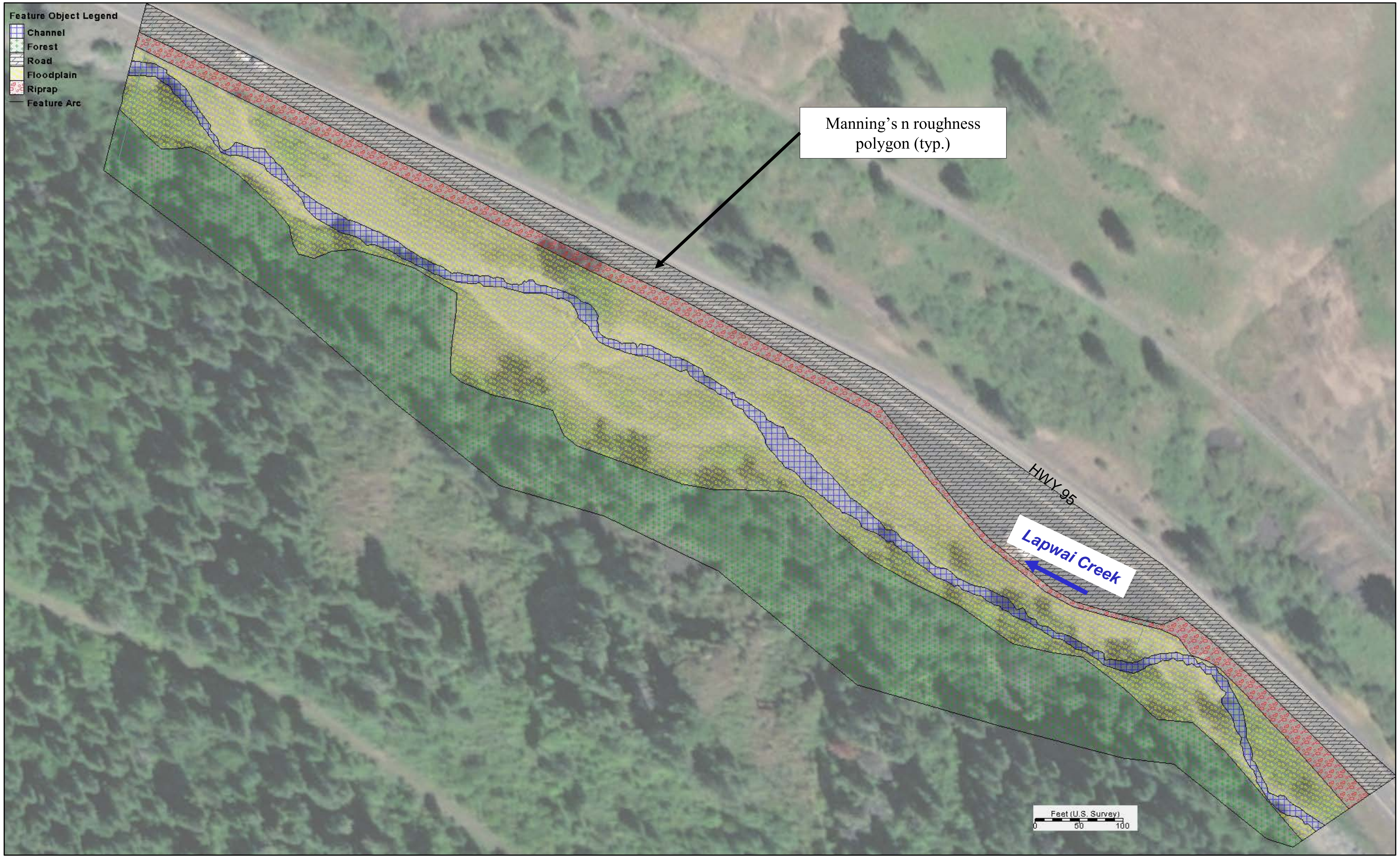
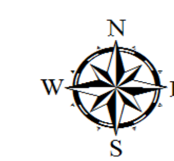
Figure C-1





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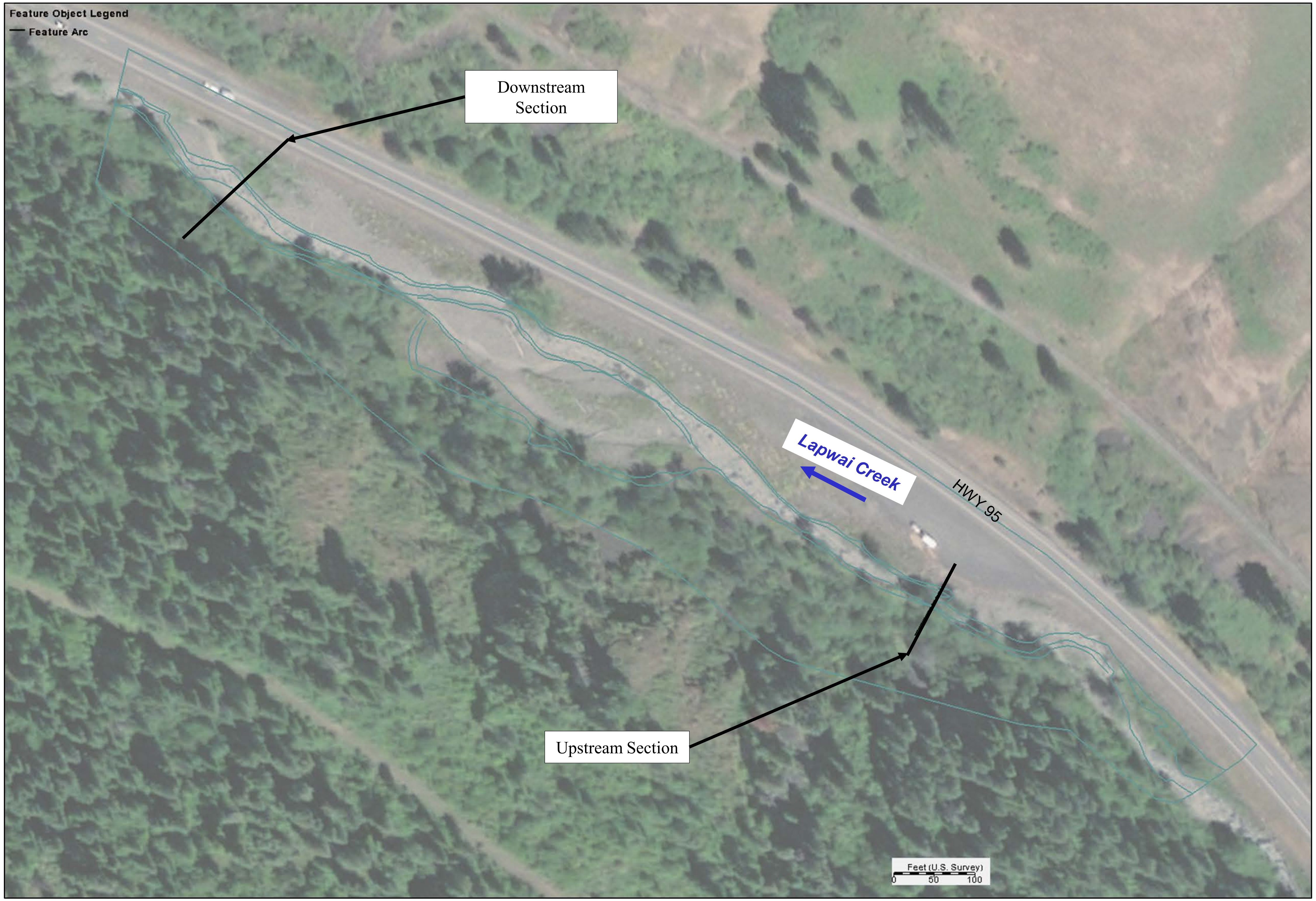
5. Vertical Projection: NAVD88

Existing Conditions Manning's n

Lapwai Creek Reach 14
Nez Perce County, Idaho

GeoEngineers

Figure C-2



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5. Vertical Projection: NAVD88

Existing Conditions Hydraulic Cross Section Extraction Locations

Lapwai Creek Reach 14
Nez Perce County, Idaho

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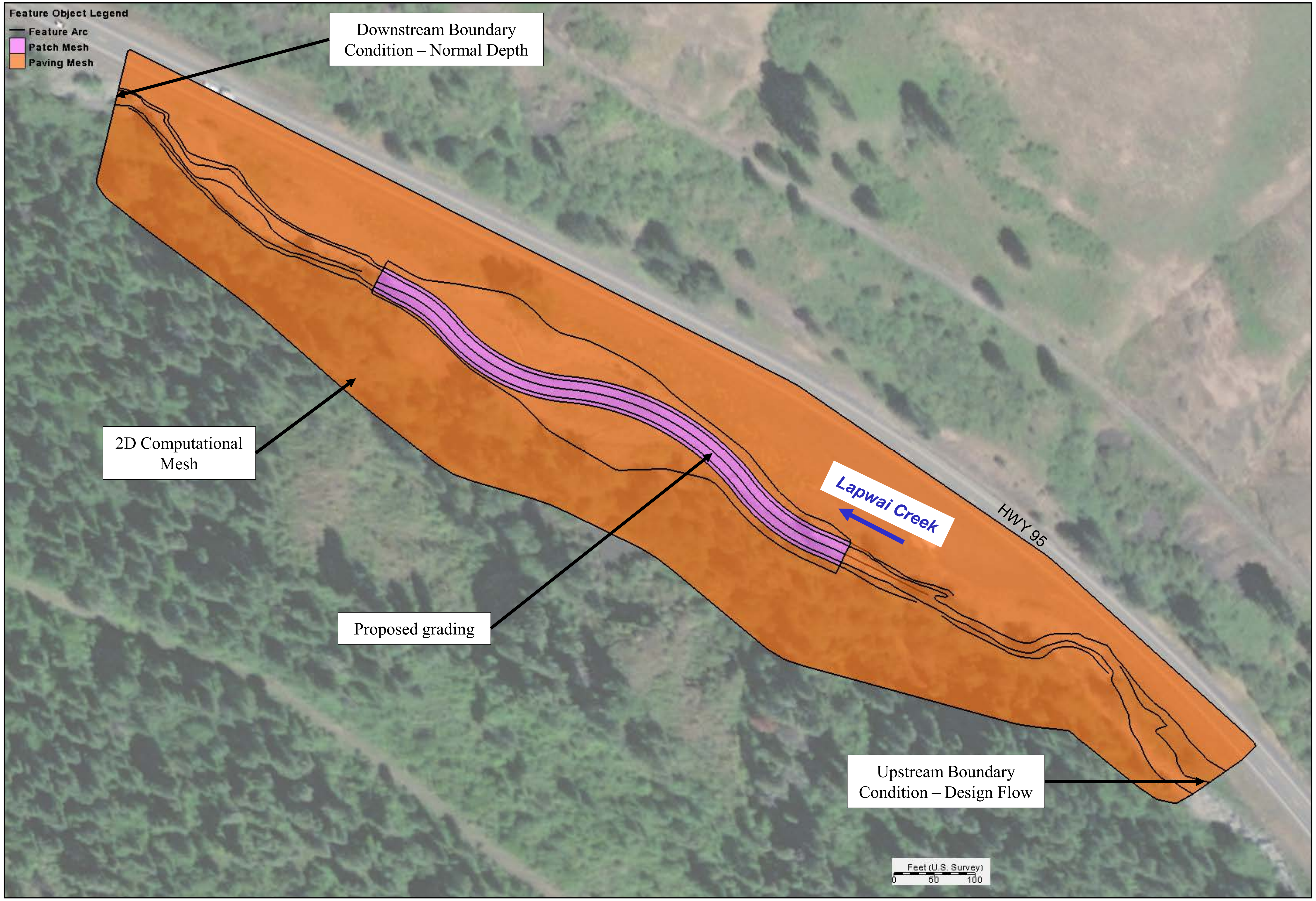
Figure C-3



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Notes:
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4. Horizontal Projection: ID State Plane, W Zone, NAD83, International Feet
5. Vertical Projection: NAVD88

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Proposed Conditions Mesh

Lapwai Creek Reach 14
Nez Perce County, Idaho

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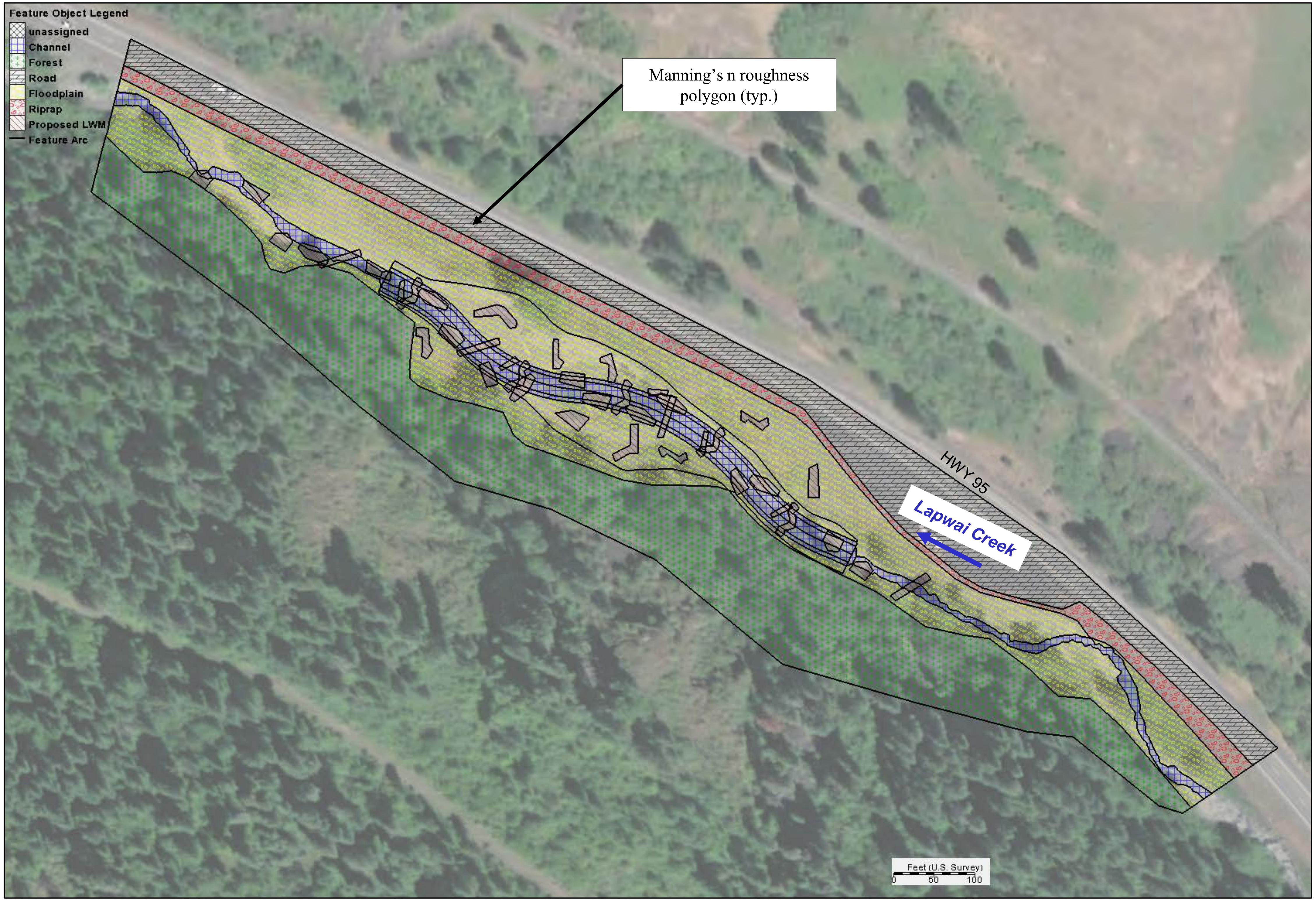
Figure C-4



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0571-022-00 Date Exported: 09/29/21

Notes:
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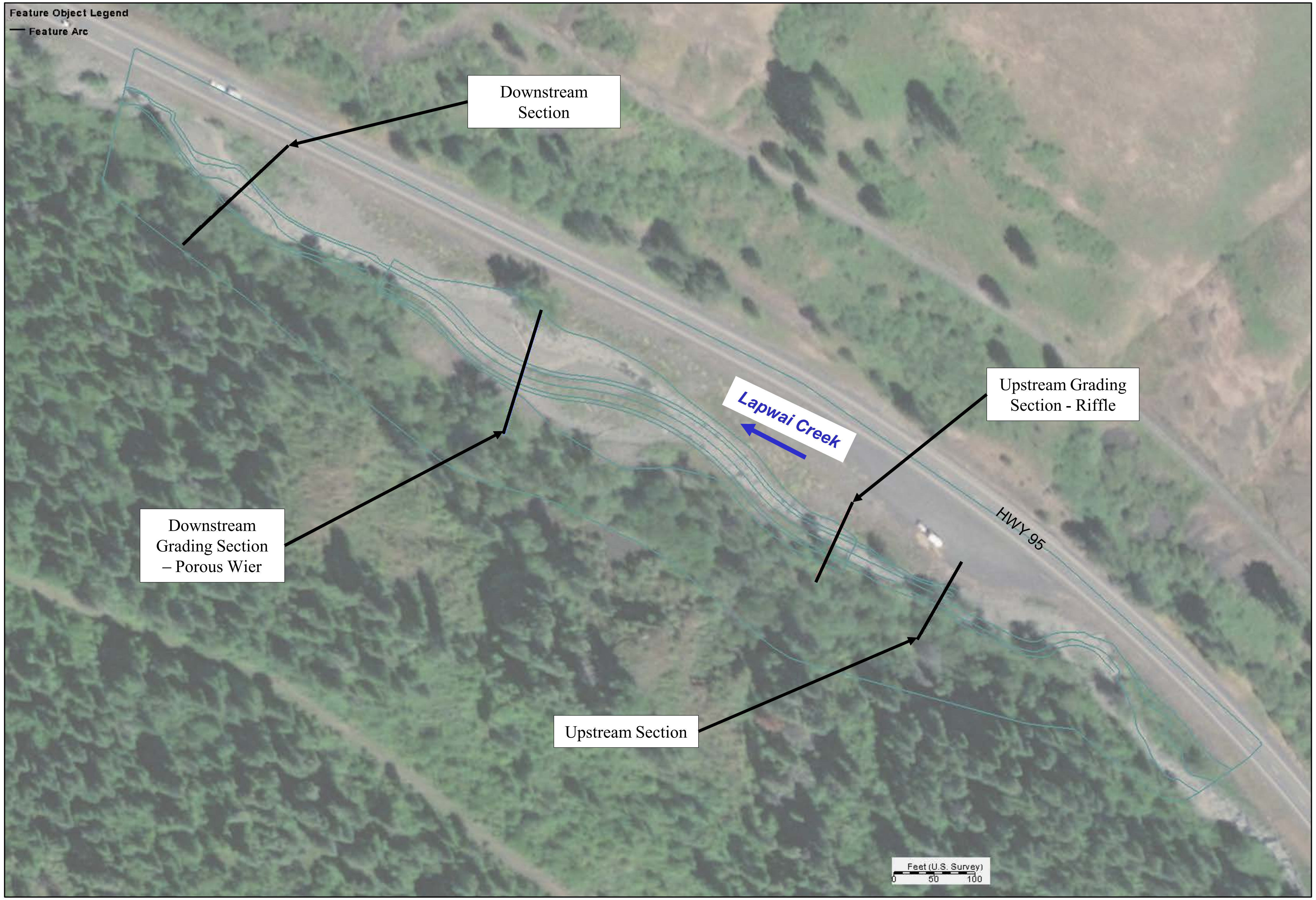
4. Horizontal Projection: ID State Plane, W Zone, NAD83, International Feet
5. Vertical Projection: NAVD88

Proposed Conditions Manning's n

Lapwai Creek Reach 14
Nez Perce County, Idaho

GEOENGINEERS

Figure C-5



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5. Vertical Projection: NAVD88

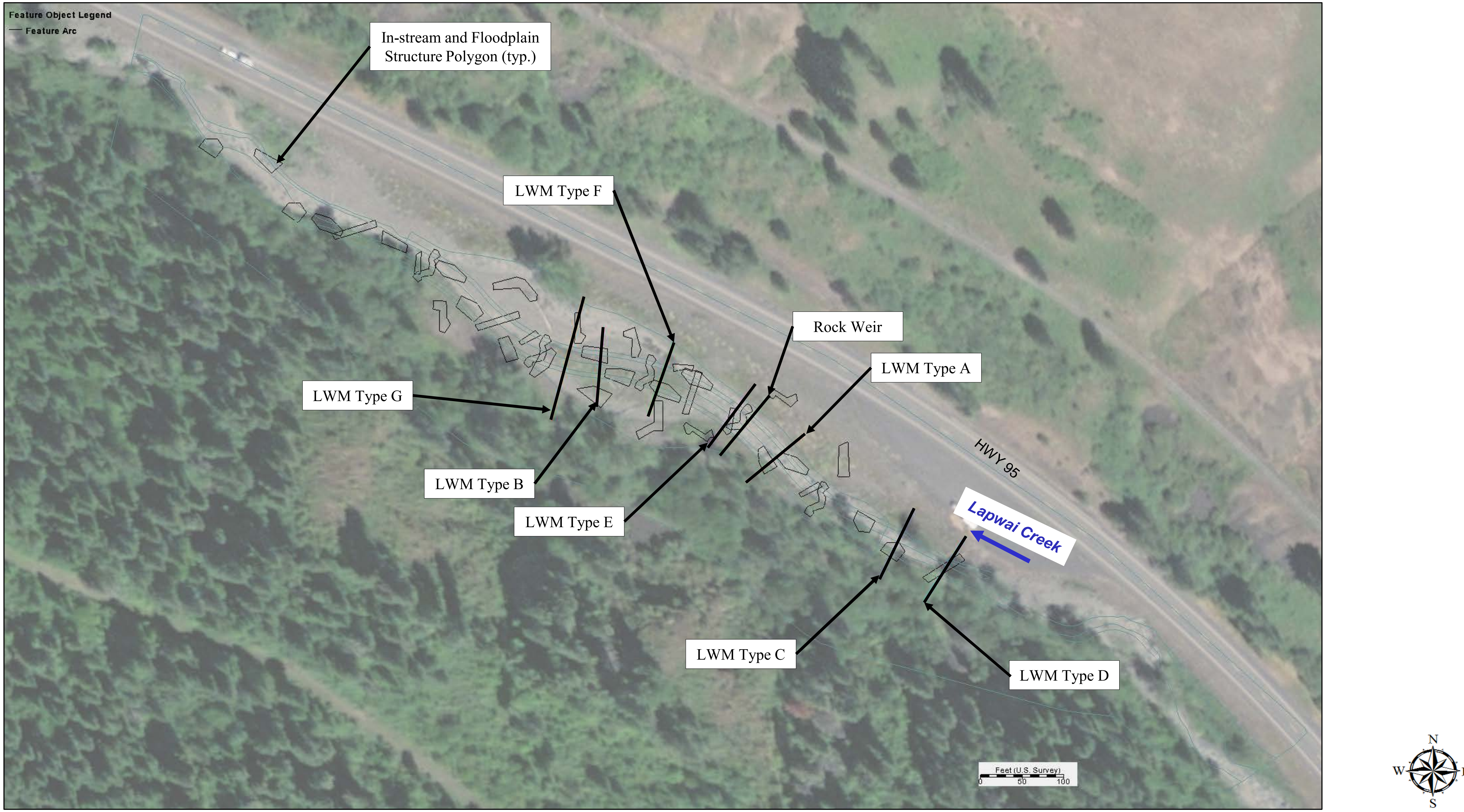
0571-022-00 Date Exported: 09/29/21

Proposed Conditions Hydraulic Cross Section Extraction Locations

Lapwai Creek Reach 14
Nez Perce County, Idaho

GeoEngineers

Figure C-6



0571-022-00 Date Exported: 09/29/21

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5. Vertical Projection: NAVD88

Hydraulic Cross Section Extraction Locations for Structure Stability

Lapwai Creek Reach 14
Nez Perce County, Idaho

GeoEngineers

Figure C-7

Water Depth (feet)

Shear Stress (pounds / square foot)

Velocity (feet / second)

Notes:

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5. Horizontal Projection: OR State Plane, N Zone, NAD83, International Feet
6. Vertical Projection: NAVD88

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Existing Conditions
Design Flow: 1.5-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure C-8

0571-022-00 Date Exported: 09/29/21

Water Depth (feet)

Shear Stress (pounds / square foot)

Velocity (feet / second)

Notes:

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6. Vertical Projection: NAVD88

Existing Conditions
Design Flow: 2-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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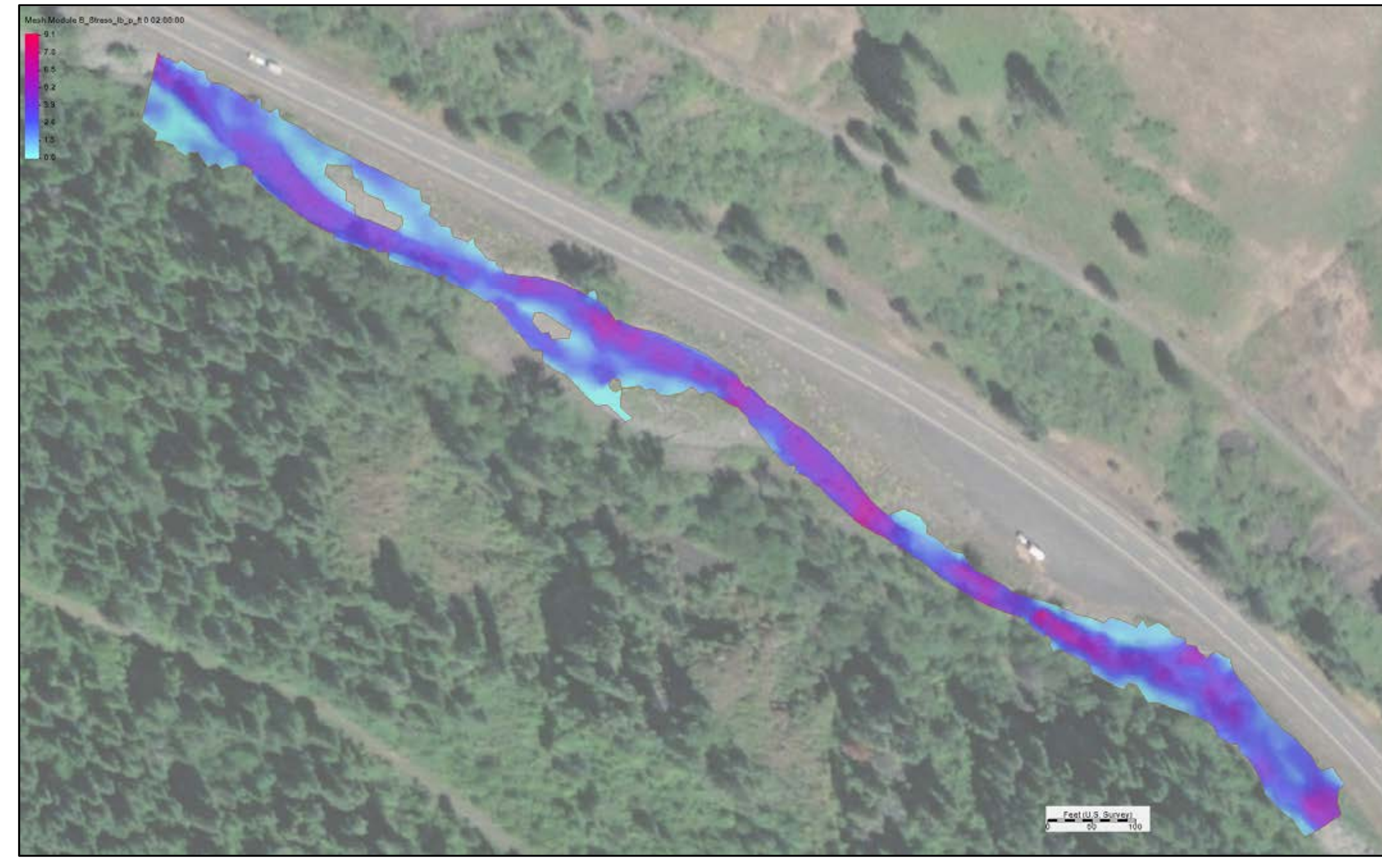
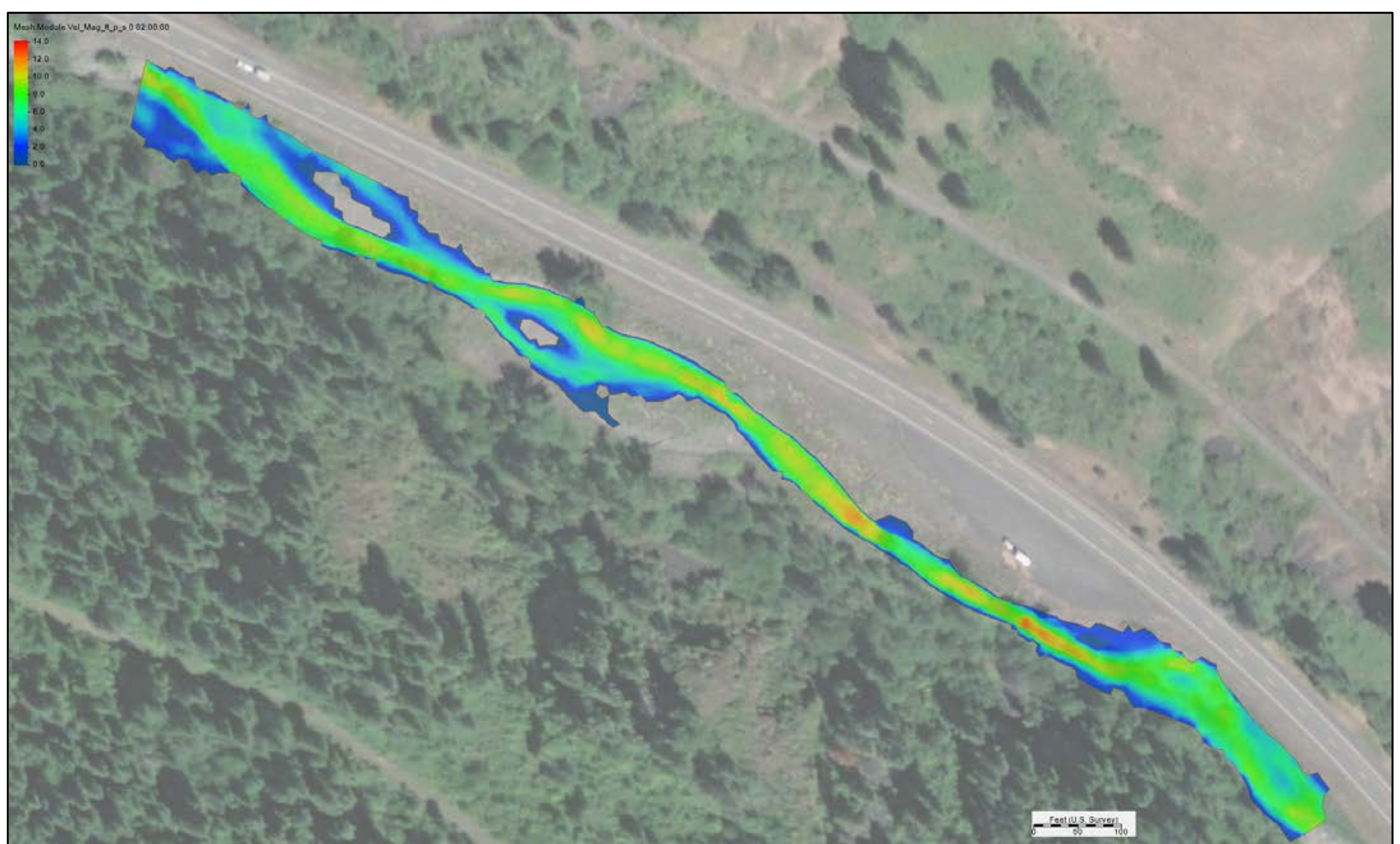
Figure C-9

0571-022-00 Date Exported: 09/29/21

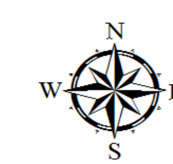
Water Depth (feet)



Shear Stress (pounds / square foot)



Velocity (feet / second)



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6. Vertical Projection: NAVD88

Existing Conditions
Design Flow: 100-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure C-10

0571-022-00 Date Exported: 09/29/21

Water Depth (feet)

Shear Stress (pounds / square foot)

Velocity (feet / second)

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5. Horizontal Projection: OR State Plane, N Zone, NAD83, International Feet
6. Vertical Projection: NAVD88

N W E S

Existing Conditions
Design Flow: April 50 Percent Exceedance

Lapwai Creek Reach 14
Nez Perce County, Idaho

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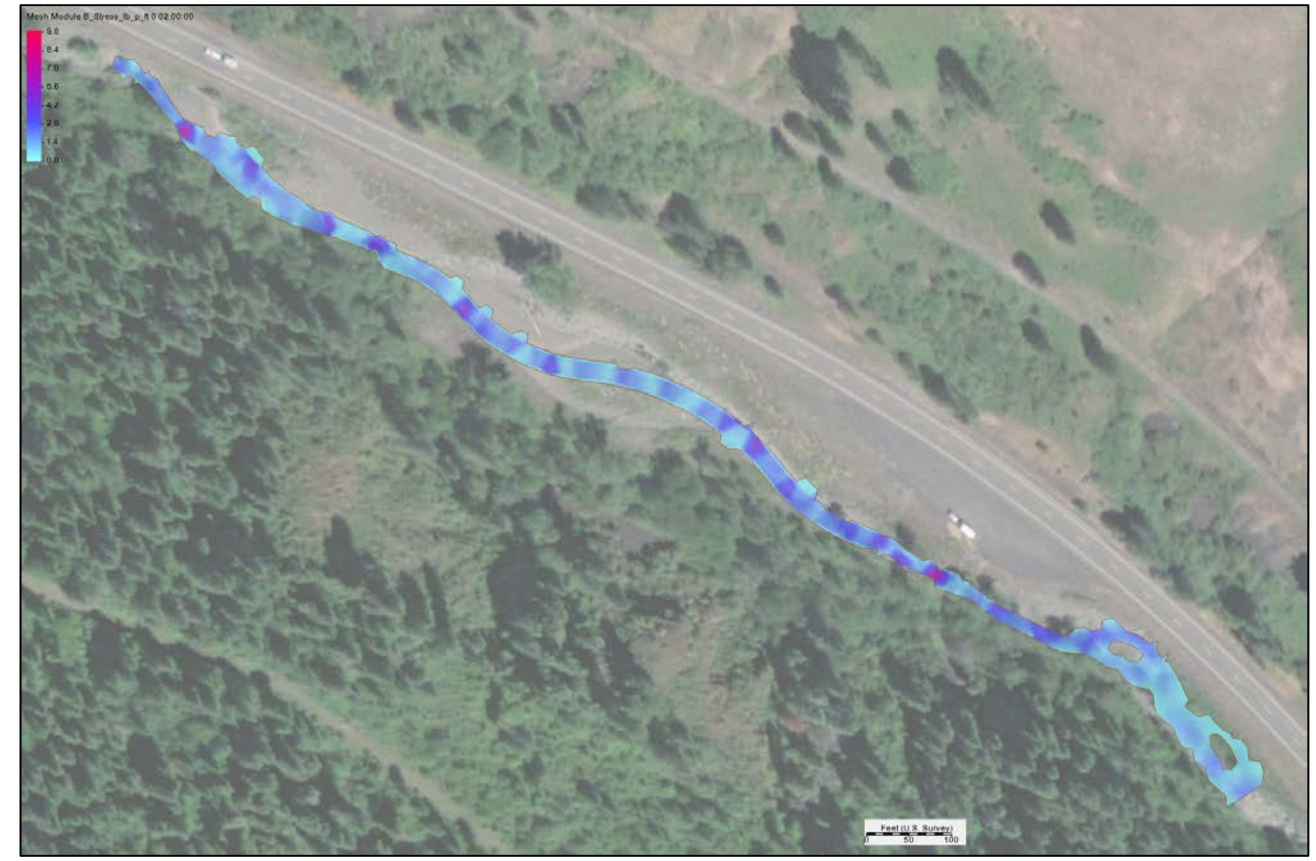
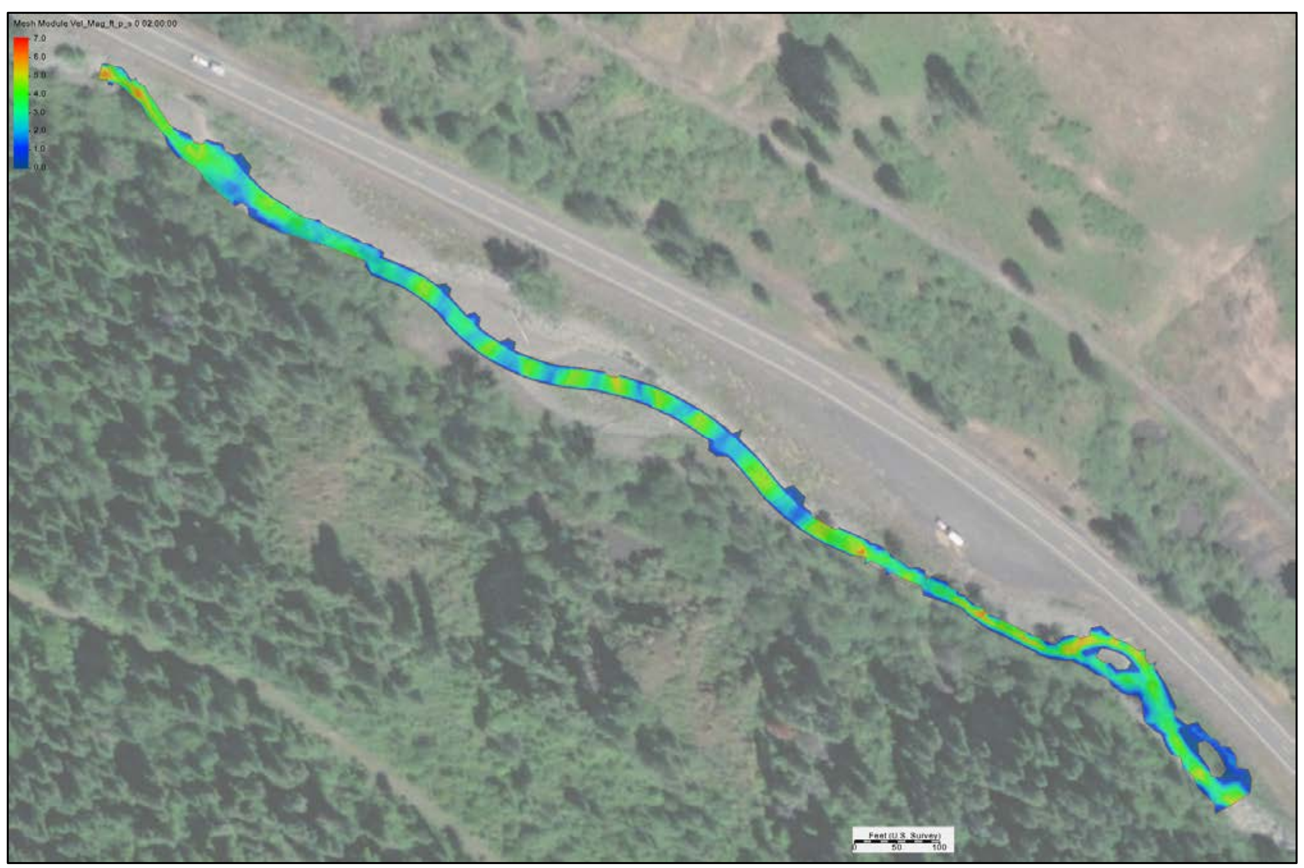
Figure C-11

0571-022-00 Date Exported: 09/29/21

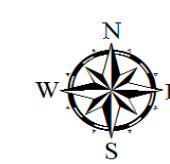
Water Depth (feet)



Shear Stress (pounds / square foot)



Velocity (feet / second)



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5. Horizontal Projection: OR State Plane, N Zone, NAD83, International Feet
6. Vertical Projection: NAVD88

Proposed Conditions
Design Flow: 1.5-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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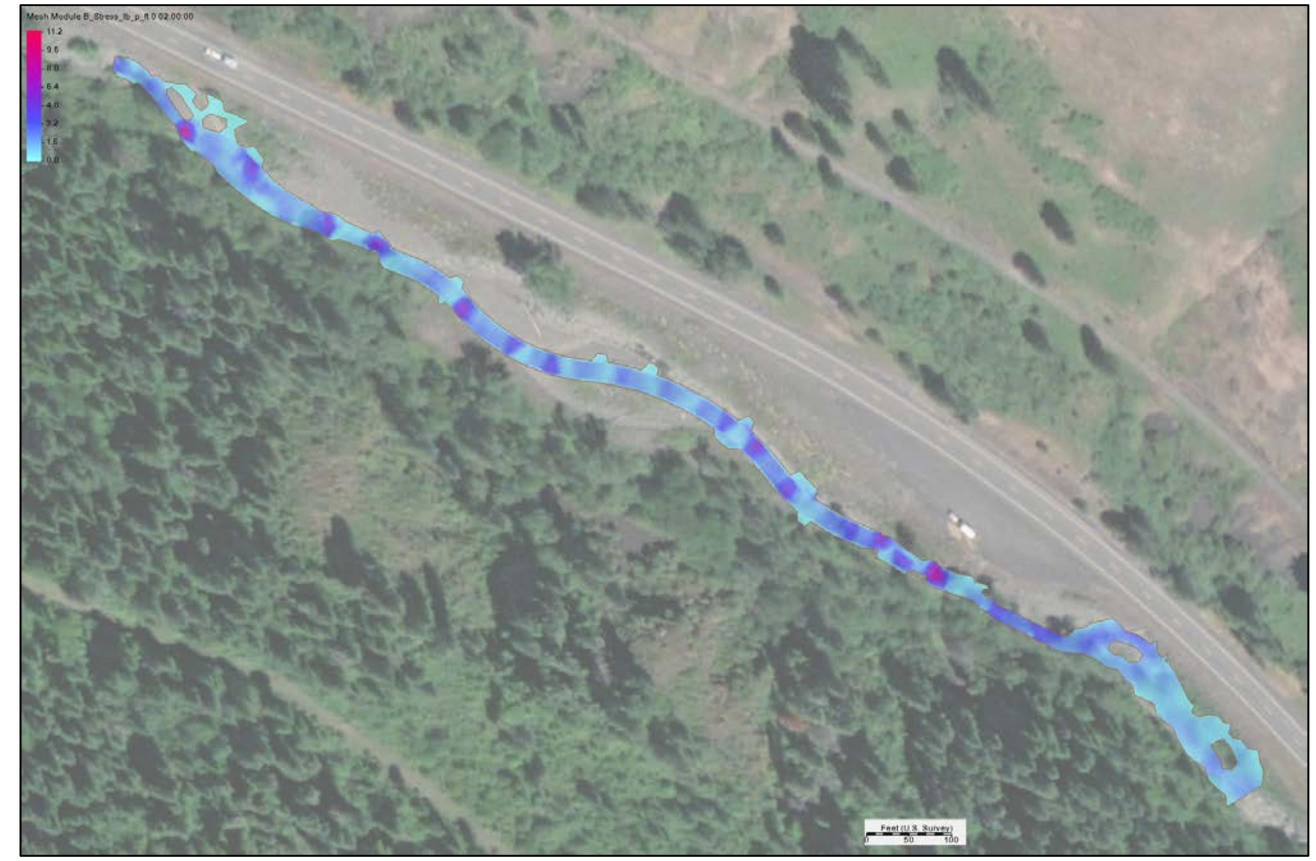
Figure C-12

0571-022-00 Date Exported: 09/29/21

Water Depth (feet)



Shear Stress (pounds / square foot)

Velocity (feet / second)

Notes:
1. The locations of all features shown are approximate.
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3. Data Source: SMS Version 13.1
4. Background aerial and existing surface from RSI (2021)
5. Horizontal Projection: OR State Plane, N Zone, NAD83, International Feet
6. Vertical Projection: NAVD88

Proposed Conditions
Design Flow: 2-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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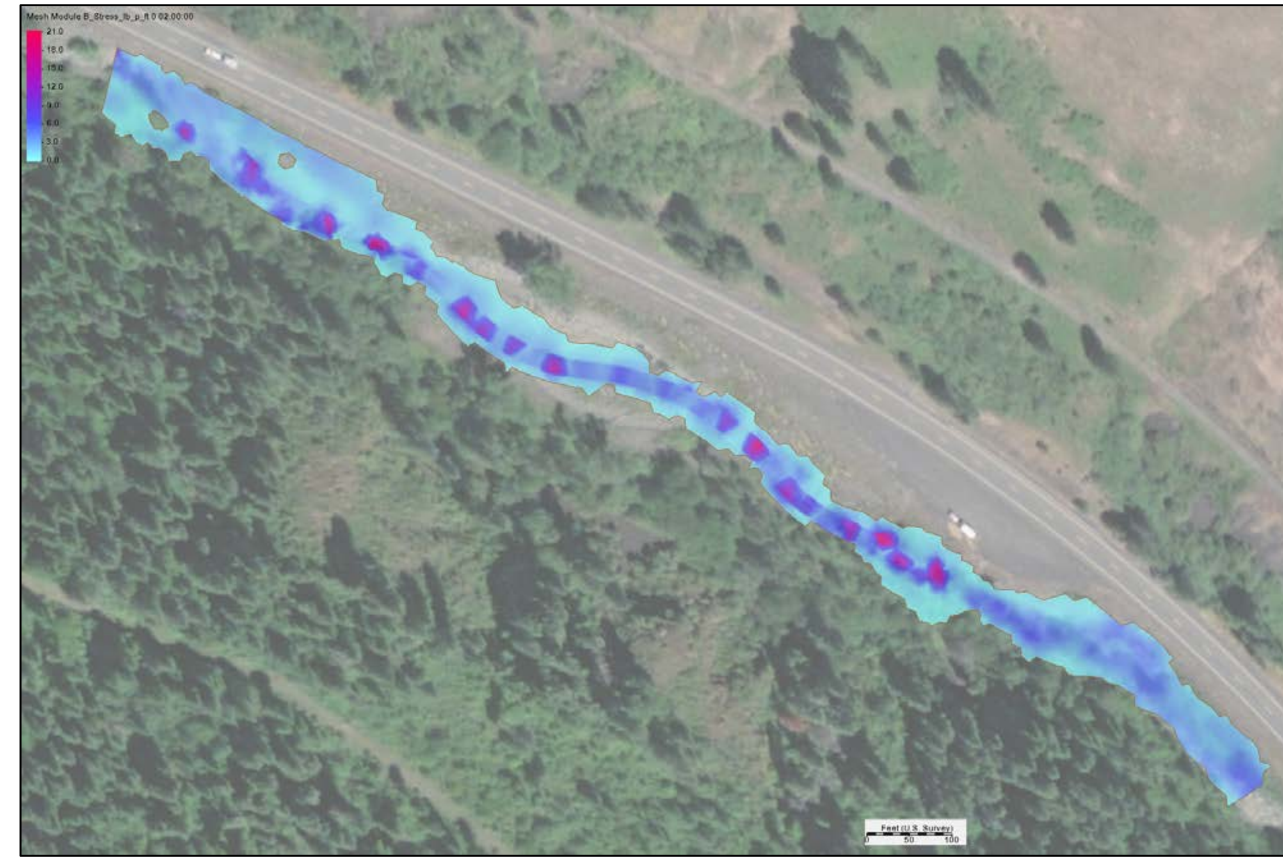
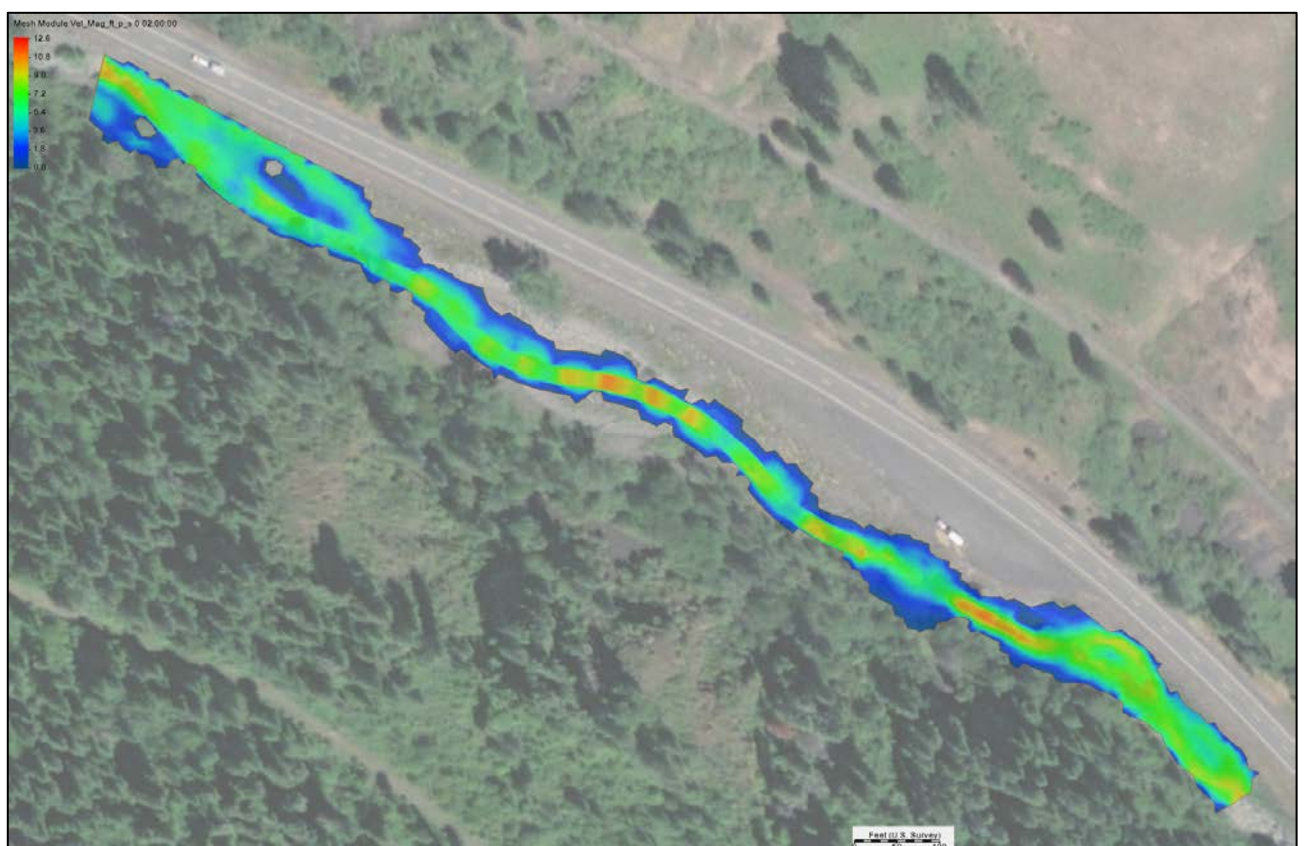
Figure C-13

0571-022-00 Date Exported: 09/29/21

Water Depth (feet)



Shear Stress (pounds / square foot)



Velocity (feet / second)

Notes:
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6. Vertical Projection: NAVD88

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Proposed Conditions
Design Flow: 100-year

Lapwai Creek Reach 14
Nez Perce County, Idaho

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Figure C-14

0571-022-00 Date Exported: 09/29/21

Water Depth (feet)

Shear Stress (pounds / square foot)

Velocity (feet / second)

Notes:

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3. Data Source: SMS Version 13.1
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5. Horizontal Projection: OR State Plane, N Zone, NAD83, International Feet
6. Vertical Projection: NAVD88

Proposed Conditions
Design Flow: April 50 Percent Exceedance

Lapwai Creek Reach 14
Nez Perce County, Idaho

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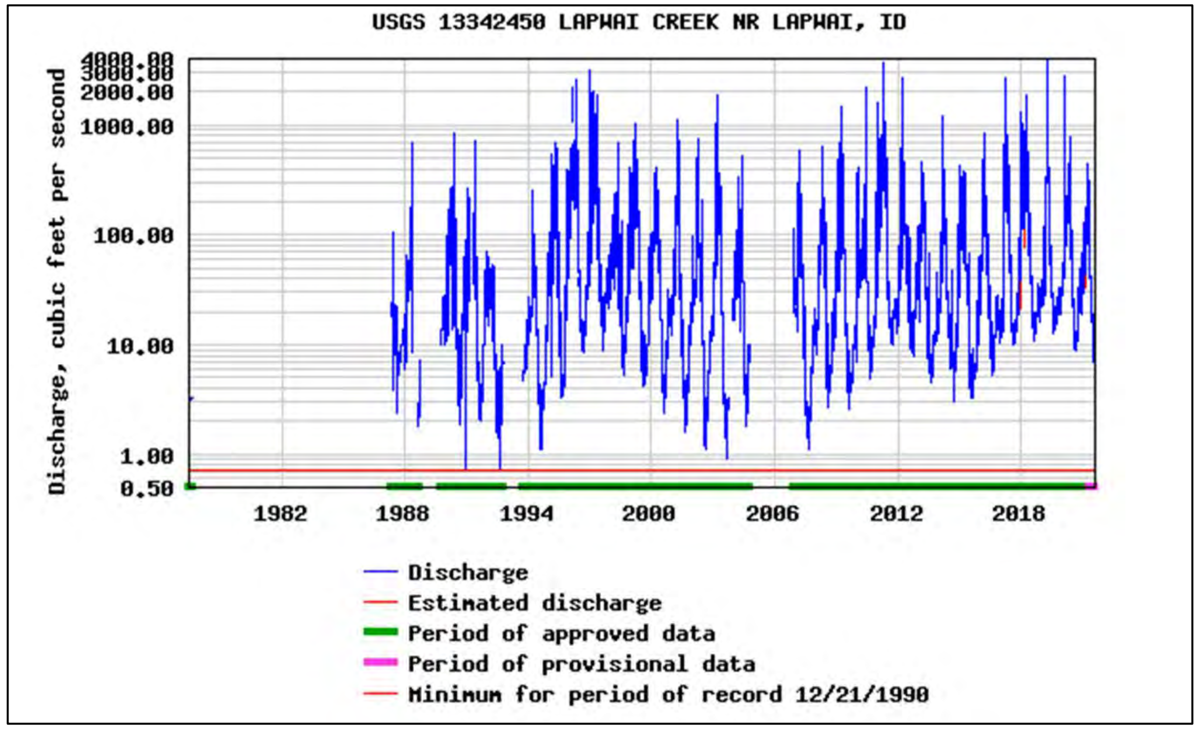
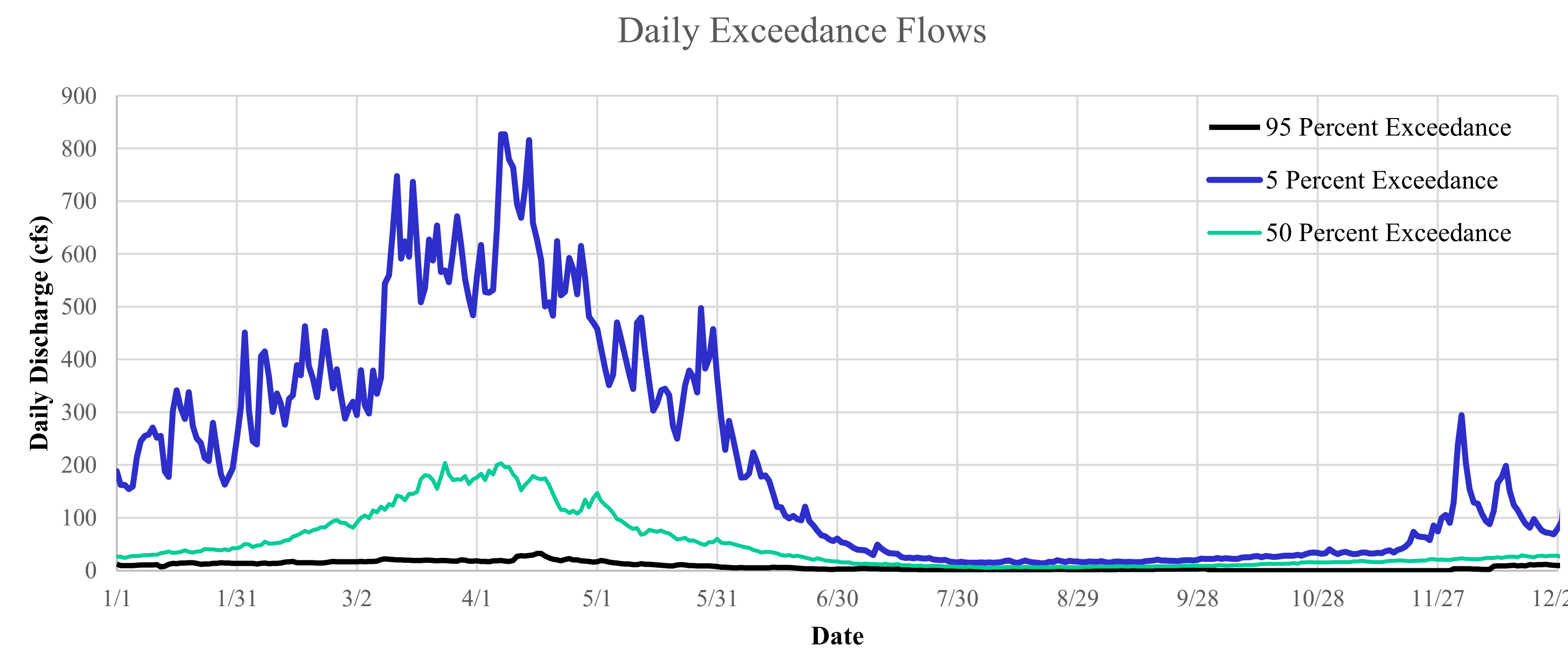
Figure C-15

0571-022-00 Date Exported: 09/29/21



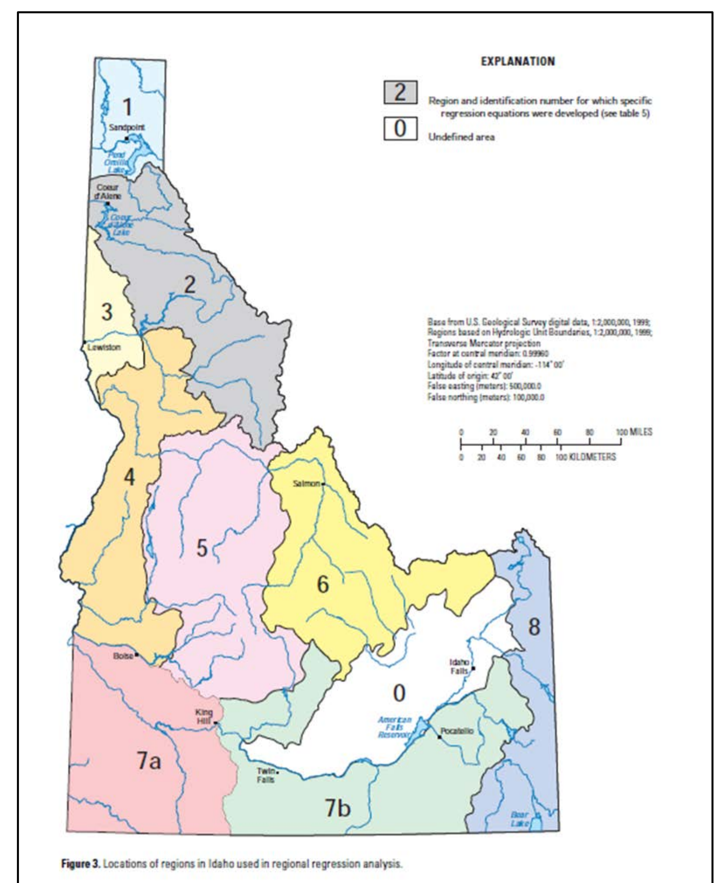
Gage Data (USGS)



Basin	Drainage Area Square Miles	Drainage Area Square Feet
Project Site	29.1	18,591.93
Gage 13342450	264.0	168,959.32

Design Flow	1.5-yr	2-yr	5-yr	10-yr	50-yr	100-yr	500-yr	August 50%	April 50%
Flow (cfs)	76	104	370	280	503	620	941	1	23

Design Flows



Scaling Regions

$$Q_u = Q_g \left(\frac{A_u}{A_g}\right)^a$$

Region 3 Scaling Equation

Recurrence Interval	Exponent a
2-year	0.864
5-year	0.842
10-year	0.837
25-year	0.833
50-year	0.832
100-year	0.831
500-year	0.832

Hydrology

Lapwai Creek Reach 14
Nez Perce County, Idaho

GeoEngineers

Figure C-16

APPENDIX D
Rock Weir Gradation

Proposed Gradation				
Location:				
	D_{100}	**D_{84}**	**D_{50}**	**D_{16}**
ft	**3.0**	**2.8**	**2.3**	**1.4**
in	**36.0**	**33.4**	**28.0**	**16.8**
mm	**914.4**	**849.4**	**711.2**	**426.7**

Location:				
	D_{100}	**D_{84}**	**D_{50}**	**D_{16}**
ft	**0.0**	**0.0**	**0.0**	**0.0**
in				
mm				

Location:				
	D_{100}	**D_{84}**	**D_{50}**	**D_{16}**
ft	**0.00**	**0.00**	**0.00**	**0.00**
in				
mm				

Location:				
	D_{100}	**D_{84}**	**D_{50}**	**D_{16}**
ft	**0.00**	**0.00**	**0.00**	**0.00**
in				
mm				

References:

8:10

Appendix E--Methods for Streambed Mobility/Stability Analysis

Limitations:

D_{84} must be between 0.40 in and 10 in

Uniform bed material (Di < 20-30 times D50)

Slopes less than 5%

Sand/gravel streams with high relative submergence

1.5yr-depth	1.2	ft
Relative Submergence:	23.3	
γ_s	165	specific weight of sediment particle (lb/ft^3)
γ	62.4	specific weight of water (1b/ft^3)
τ_{D50}	0.045	dimensionless Shields parameter for D50, use table E.1 of USFS manual or assume 0.045 for poorly sorted channel bed

Existing Gradation: https://projects.geoengineers.com/sites/0057102100/Technical%20Analysis/Sediment/Poley-Allen_ExistingGrad

Link to Model Results: https://projects.geoengineers.com/sites/0057102200/Final/80%

Determining Aggregate Proportions

Per WSDOT Standard Specifications 9-03.11

	Flow	Prop 1.5-YR	Prop 100-YR
Average Modeled Shear Stress (lb/ft^2)		1.70	3.70

	Rock Size [in]	Rock Size [mm]	Streambed Sediment	Streambed Cobbles 4"	6"	8"	10"	12"	Streambed Boulders 12"-18"	18"-28"	28"-36"	D_{size}	τ_{ci}				
	36.0	**914**									**100**	**100.0**	11.62	No Motion	No Motion	No Motion	No Motion
	32.0	**813**									50	**75.0**	11.21	No Motion	No Motion	No Motion	No Motion
	28.0	**711**								**100**		**50.0**	10.77	No Motion	No Motion	No Motion	No Motion
	23.0	**584**								50		**35.0**	10.16	No Motion	No Motion	No Motion	No Motion
	18.0	**457**							**100**			**20.0**	9.44	No Motion	No Motion	No Motion	No Motion
	15.0	**381**							50			**10.0**	8.93	No Motion	No Motion	No Motion	No Motion
	12.0	**305**						**100**				**0.0**	8.35	No Motion	No Motion	No Motion	No Motion
	10.0	**254**					**100**	**80**				**0.0**	7.91	No Motion	No Motion	No Motion	No Motion
	8.0	**203**				**100**	**80**	68				**0.0**	7.40	No Motion	No Motion	No Motion	No Motion
	6.0	**152**			**100**	**80**	68	57				**0.0**	6.79	No Motion	No Motion	No Motion	No Motion
	5.0	**127**			**80**	68	57	**45**				**0.0**	6.43	No Motion	No Motion	No Motion	No Motion
	4.0	**102**		**100**	71	57	**45**	39				**0.0**	6.01	No Motion	No Motion	No Motion	No Motion
	3.0	**76.2**		**80**	63	**45**	38	34				**0.0**	5.51	No Motion	No Motion	No Motion	No Motion
	2.5	**63.5**	**100**	65	54	37	32	28				**0.0**	5.22	No Motion	No Motion	No Motion	No Motion
	2.0	**50.8**	**80**	50	**45**	29	25	22				**0.0**	4.88	No Motion	No Motion	No Motion	No Motion
	1.5	**38.1**	73	**35**	32	21	18	16				**0.0**	4.48	No Motion	No Motion	No Motion	No Motion
	1.0	**25.4**	**65**	20	18	13	12	11				**0.0**	3.96	No Motion	No Motion	No Motion	No Motion
	0.75	**19.1**	50	**5**	**5**	**5**	**5**	**5**				**0.0**	3.64	No Motion	Motion	No Motion	No Motion
No. 4	**0.19**	**4.75**	**35**									**0.0**					
o. 40	**0.02**	**0.425**	**16**									**0.0**					
. 200	**0.00**	**0.0750**	**7**									**0.0**					
	% per category								**20**	**30**	**50**	*--> 100%*					
	% Cobble & Sediment											*0.0%*					

D16	16.8	in
D50	28.0	in
	2.3	ft
D84	33.4	in
D100	36.0	in

APPENDIX E
Large Wood Stability Calculations

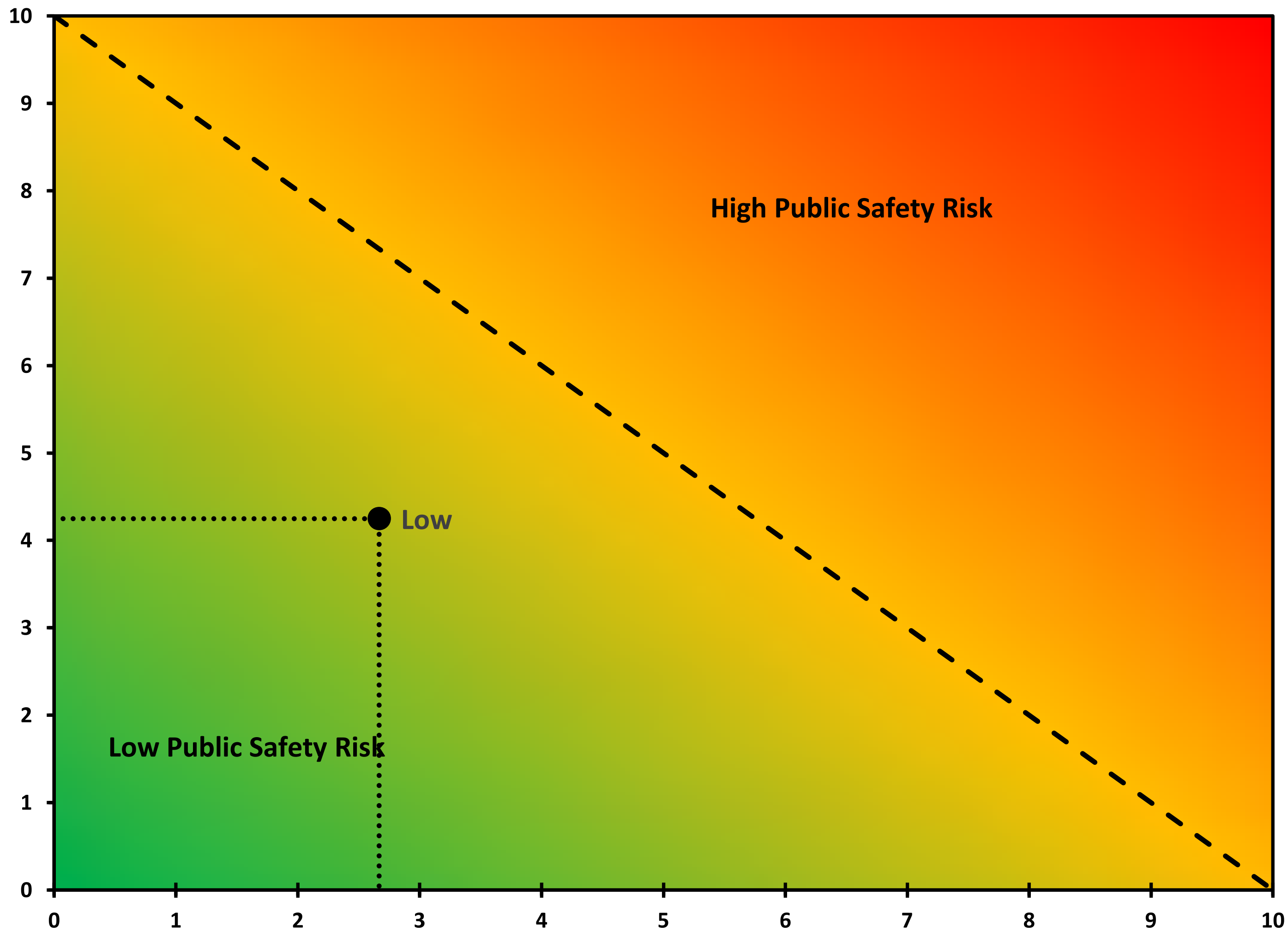
Public Safety Risk Matrix

Structure Description: Proposed LWM

Reach-User Characteristics

			Score
Low	Frequency of Use	High	2
Advanced	Skill Level	Beginner	6
Poor	Access	Good	7
Never	Child Presence	Often	2
		Total	17.0

Average Score = 4.3



Structure Characteristics

			Score
No	Active Channel?	Yes	1
No	Outside of Bend?	Yes	3
Low	Strainer Potential	High	4
High	Egress Potential	Low	2
High	Sight Distance	Low	2
Low	Depth x Velocity	High	4

Average Score = 2.7

Total Score = 16.0

Project:
Lapwai Creek Restoration

Evaluator:
A. Morton

Concurrence:
R. Carnie

Date:
7/30/2021

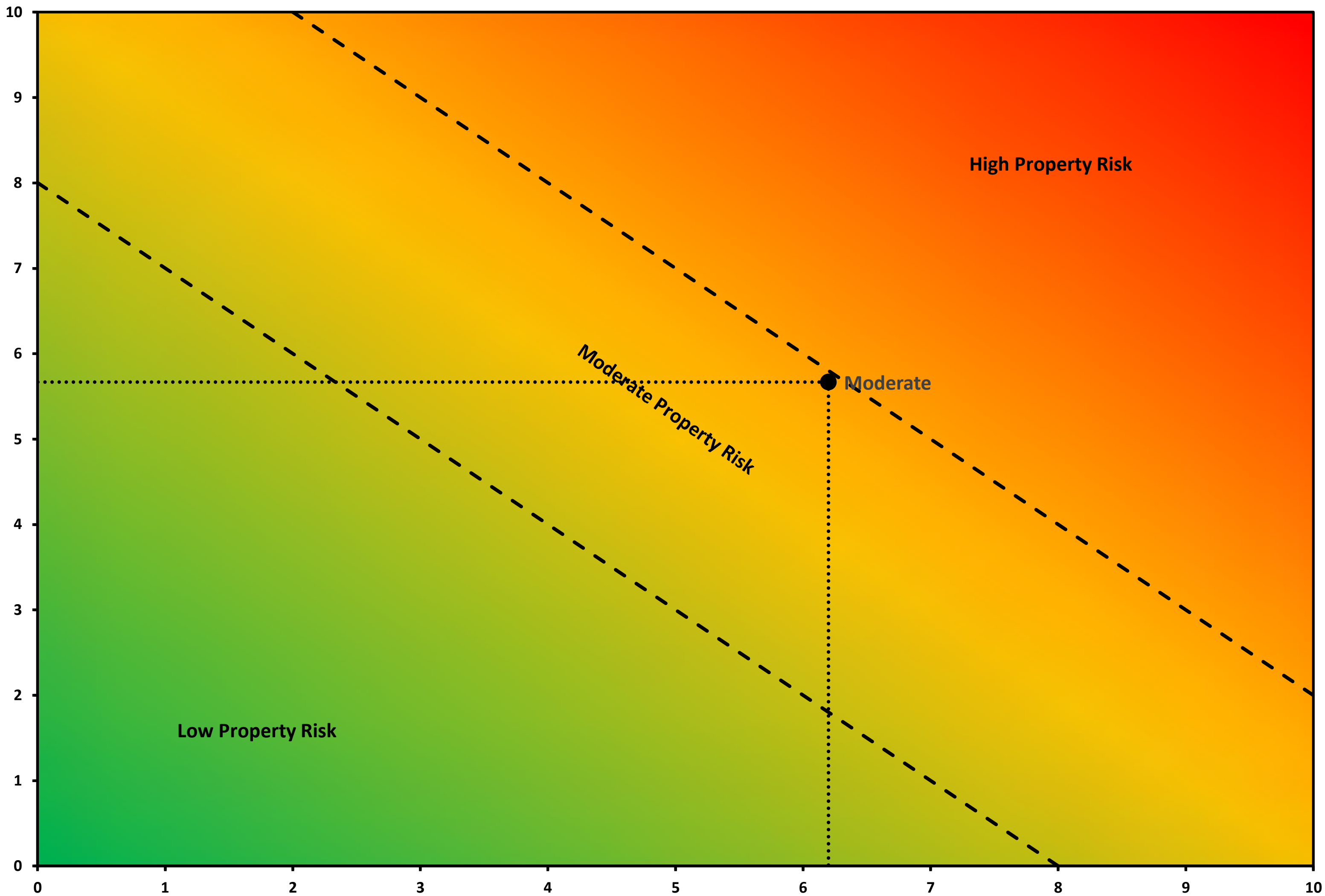
Property Damage Risk Matrix

Structure Description: Proposed LWM

Property/Project Characteristics

			Score
In-Channel Structures	No Structures	Multiple	4
Floodplain Structures	No Buildings	Multiple	7
Land Use	National Forest	Residential	6
		Total =	17.0

Average Score = 5.7



Project:
Lapwai Creek Restoration

Evaluator:
A. Morton

Concurrence:
R. Carnie

Date:
7/30/2021

Stream Response Potential

					Score
Stream Type:	Bedrock (source >10%)		Transport (3-10%)	Response (<3%)	4
Riparian Corridor:	Continuous/Wide		Discontinuous/narrow	Urbanized/Levee Confined	7
Bed Scour:	Boulder/Clay bed		Gravel/Cobble	Sand/Silt	7
Hydrologic Regime:	Spring-fed	Snowmelt	Rain / Rain-on-Snow	Thunderstorm	7
Bank Erosion:	Naturally Non-erodible		Erosion Resistant	Highly Erodible	6

Average Score = 6.2

Total Score = 31.0

Lapwai Creek Reach 14
Factors of Safety and Design Constants

Spreadsheet developed by
Michael Rafferty, P.E.

Symbol	Description	Value
FS_V	Factor of Safety for Vertical Force Balance	**1.75**
FS_H	Factor of Safety for Horizontal Force Balance	**1.50**
FS_M	Factor of Safety for Moment Force Balance	**1.50**

Symbol	Description	Units	Value
C_{Lrock}	Coefficient of lift for submerged boulder (D'Aoust, 2000)	-	0.17
C_{Drock}	Coefficient of drag for submerged boulder (Schultz, 1954)	-	0.85
g	Gravitational acceleration constant	ft/s^2	32.174
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-	3.00
LF_{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-	1.50
SG_{rock}	Specific gravity of quartz particles	-	2.65
γ_{rock}	Dry unit weight of boulders	lb/ft^3	165.0
γ_w	Specific weight of water at 50ºF	lb/ft^3	62.40
η	Rootwad porosity from NRCS Tech Note 15 (2001)	-	0.20
ν	Kinematic viscosity of water at 50ºF	ft/s^2	1.41E-05

Lapwai Creek Reach 14
Hydrologic and Hydraulic Inputs

Spreadsheet developed by
Michael Rafferty, P.E.

Average Return Interval (ARI) of Design Discharge: 100 yr

Site ID	Proposed Station	Design Discharge, Q_{des} (cfs)	Maximum Depth, d_w (ft)	Average Velocity, u_{avg} (ft/s)	Bankfull Width, W_{BF} (ft)	Wetted Area, A_W (ft^2)	Radius of Curvature, R_c (ft)
Type A	8+50	620	3.9	4.1	32.0	68.7	1,000.0
Type B	6+00	620	3.7	3.3	32.0	68.7	1,000.0
Type C	10+25	620	4.70	5.95	32.0	69	1,000
Type D	10+90	620	5.38	2.62	32.0	69	1,000
Type E	7+70	620	3.4	4.1	32.0	68.7	1,000
Type F	6+75	620	3.64	3.42	32.0	69	200
Type G	5+60	620	3.44	2.81	32.0	69	1,000

Lapwai Creek Reach 14
Stream Bed Substrate Properties

Spreadsheet developed by
Michael Rafferty, P.E.

Site ID	Proposed Station	Stream bed D_{50} (mm)	Stream Bed Substrate Grain Size Class	Bed Soil Class	Dry Unit Weight[1], γ_{bed} (lb/ft^3)	Buoyant Unit Weight, γ'_{bed} (lb/ft^3)	Friction Angle, ϕ_{bed} (deg)
Type A	8+50	70.40	Small Cobble	4	134.5	83.7	41
Type B	6+00	70.40	Small Cobble	4	134.5	83.7	41
Type C	10+25	70.40	Small Cobble	4	134.5	83.7	41
Type D	10+90	70.40	Small Cobble	4	134.5	83.7	41
Type E	7+70	70.40	Small Cobble	4	134.5	83.7	41
Type F	6+75	70.40	Small Cobble	4	134.5	83.7	41
Type G	5+60	70.40	Small Cobble	4	134.5	83.7	41

Source: Compiled from Julien (2010) and Shen and Julien (1993); soil classes from NRCS Table TS14E–2 Soil classification

[1] γ_{bed} (kg/m^3) = 1,600 + 300 log D_{50} (mm) (from Julien 2010)

1 kg/m^3 = 0.062 1 lb/ft^3

Lapwai Creek Reach 14
Bank Soil Properties

Spreadsheet developed by
Michael Rafferty, P.E.

Site ID	Proposed Station	Bank Soils (from field observations)	Bank Soil Class	Dry Unit Weight, γ_{bank} (lb/ft^3)	Buoyant Unit Weight, γ'_{bank} (lb/ft^3)	Friction Angle, ϕ_{bank} (deg)
Type A	8+50	**Gravel/cobble**	4	137.0	85.3	41
Type B	6+00	**Gravel/cobble**	4	137.0	85.3	41
Type C	10+25	**Gravel/cobble**	4	137.0	85.3	41
Type D	10+90	**Gravel/cobble**	4	137.0	85.3	41
Type E	7+70	**Gravel/cobble**	4	137.0	85.3	41
Type F	6+75	**Gravel/cobble**	4	137.0	85.3	41
Type G	5+60	**Gravel/cobble**	4	137.0	85.3	41

Lapwai Creek Reach 14
Large Wood Properties

Spreadsheet developed by
Michael Rafferty, P.E.

Project Location: Mountain West

Timber Unit Weights			Air-dried[1] γ_{Td} (lb/ft^3)	Green[2] γ_{Tgr} (lb/ft^3)
Selected Species	Common Name	Scientific Name		
Tree Type #1:	Douglas-fir, Interior north	Pseudotsuga menziesii var. glauca	33.5	38.0
Tree Type #2:				
Tree Type #3:				
Tree Type #4:				
Tree Type #5:				
Tree Type #6:				
Tree Type #7:				
Tree Type #8:				
Tree Type #9:				
Tree Type #10:				

[1] **Air-dried unit weight,** γ_{Td} = Average unit weight of wood after exposure to air on a 12% moisture content volume basis. Air-dried unit weight is used in the force balance calculations for the portion of wood that is above the proposed thalweg elevation (assuming unsaturated conditions).

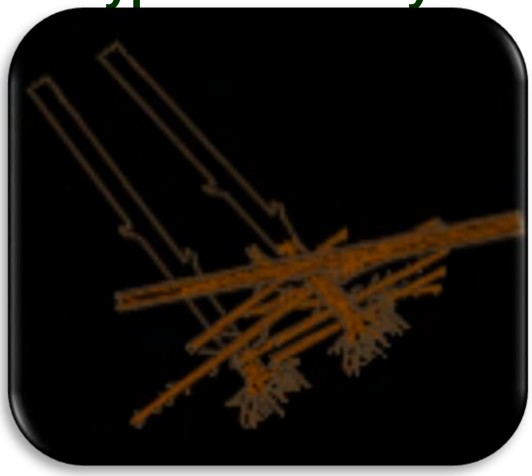
[2] **Green unit weight,** γ_{Tgr} = Average unit weight of freshly sawn wood when the cell walls are completely saturated with water. Green unit weight is used in the force balance calculations as a conservative estimate of the unit weight for the portion of wood that is below the proposed thalweg elevation (assuming saturated conditions). For comparison, Thevenet, Citterio, & Piegay (1998) determined wood unit weight typically increases by more than 100% after less than 24 hours exposure to water.

Source for timber unit weights:

U.S. Department of Agriculture, U.S. Forest Service. (2009) Specific Gravity and Other Properties of Wood and Bark for 156 Tree Species Found in North America. Research Note NRS-38. Table 1A.

Lapwai Creek Reach 14

LWM Type A Stability Analysis



Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. ***Computational Design Tool for Evaluating the Stability of Large Wood Structures.*** **Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.**

Lapwai Creek Reach 14

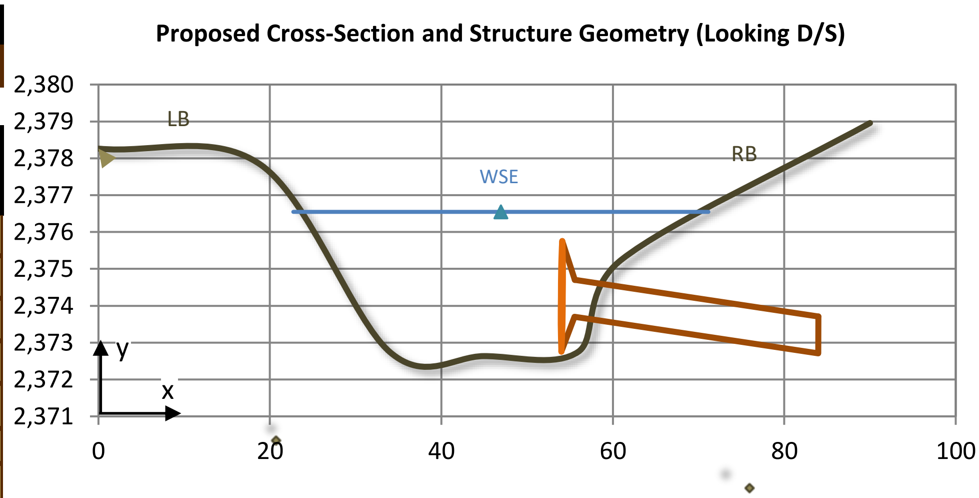
Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type A	Rootwad	Right bank	Straight	8+50	3.91	31.25	4.11

Multi-Log Structures	Layer	Log ID
	N/A	RW#1

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,378.3
Top LB	19.0	2,377.8
Toe LB	34.0	2,372.7
Thalweg	45.0	2,372.6
Toe RB	56.0	2,372.8
Top RB	61.0	2,375.2
Fldpln RB	90.0	2,379.0

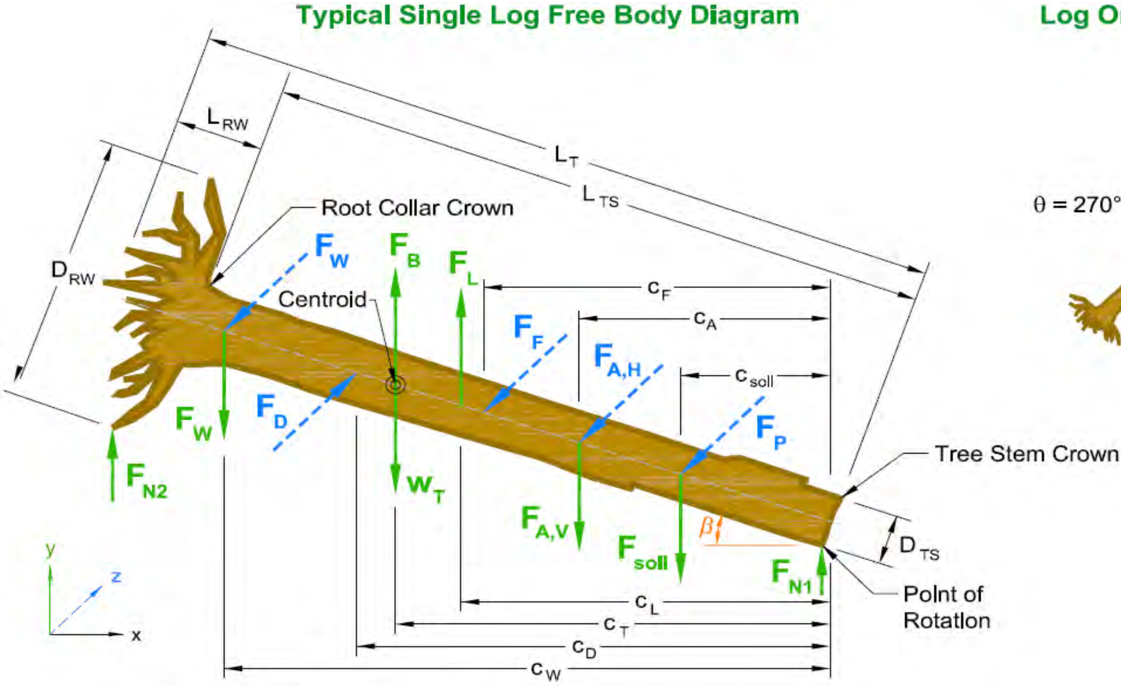


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

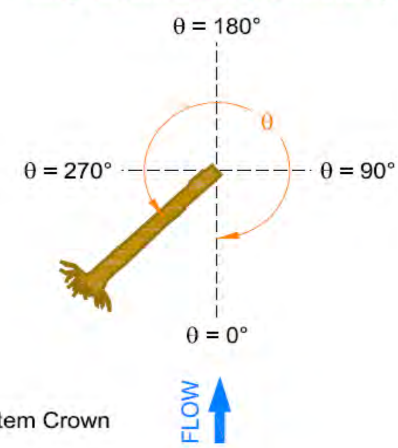
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	274.0	-2.0	Rootwad: Bottom	54.00	2,372.76	2,372.71	2,375.76	5.05

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	φ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	24.43	4.48	2.49

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.4	4.1	26.5	888	1,652
↓Thalweg	0.0	0.0	0.0	0	0
Total	22.4	4.1	26.5	888	1,652

Lift Force

C_{LT}	0.04
F_L (lbf)	3

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	3	↑
W_T (lbf)	888	↓
F_{soil} (lbf)	5,713	↓
$F_{W,V}$ (lbf)	397	↓
$F_{A,V}$ (lbf)	0	
ΣF_V (lbf)	5,343	↓
FS_V	4.23	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	10.5	50.0	60.6	5,713
Total	10.5	50.0	60.6	5,713

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.07	0.73	1.10	0.22	1.54	128

Horizontal Force Balance

F_D (lbf)	128	→
F_P (lbf)	13,754	←
F_F (lbf)	4,645	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
ΣF_H (lbf)	18,271	←
FS_H	144.19	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	328
Bank	4.81	13,754	26.32	0.87	4,317
Total	-	13,754	28.32	-	4,645

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	26.8	27.2	16.6	12.2	13.1	16.2

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	30,952
M_r (lbf)	441,762
FS_M	14.27

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Applied Forces from other Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-397	-3,050	397	↓	0
								0
								0
								0

Lapwai Creek Reach 14

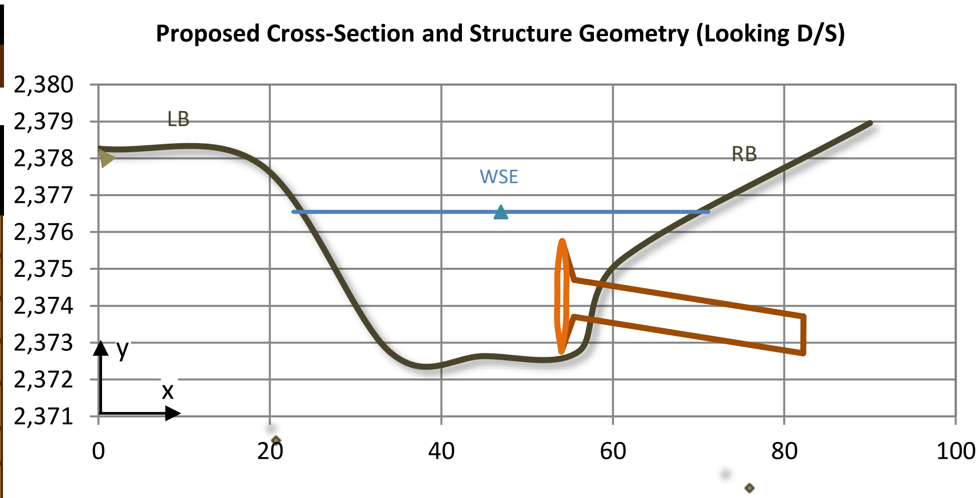
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type A	Rootwad	Right bank	Straight	8+50	3.91	31.25	4.11

Multi-Log Structures	Layer	Log ID
	N/A	RW#2

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,378.3
Top LB	19.0	2,377.8
Toe LB	34.0	2,372.7
Thalweg	45.0	2,372.6
Toe RB	56.0	2,372.8
Top RB	61.0	2,375.2
Fldpln RB	90.0	2,379.0

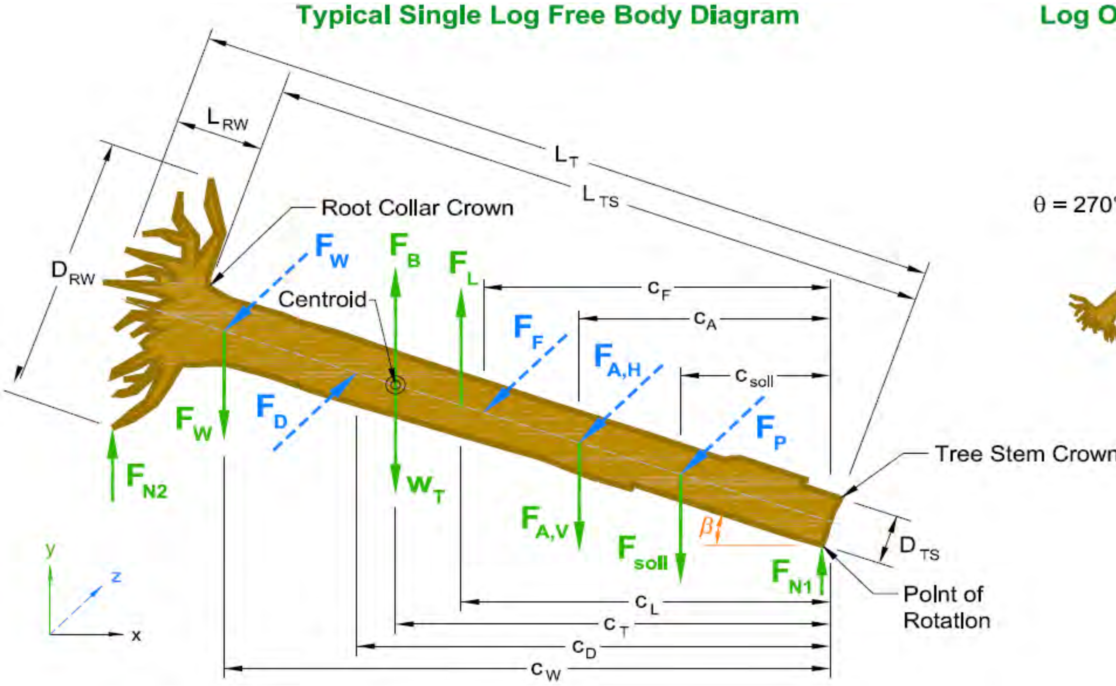


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

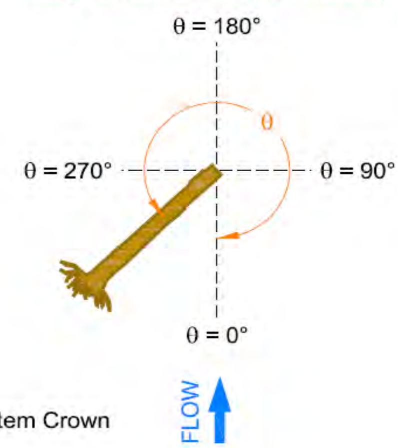
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	290.0	-2.0	Rootwad: Bottom	54.00	2,372.76	2,372.71	2,375.76	6.97

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	24.11	4.26	2.38

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.4	4.1	26.5	888	1,652
↓Thalweg	0.0	0.0	0.0	0	0
Total	22.4	4.1	26.5	888	1,652

Lift Force

C_{LT}	0.04
F_L (lbf)	5

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	5	↑
W_T (lbf)	888	↓
F_{soil} (lbf)	5,309	↓
$F_{W,V}$ (lbf)	397	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	4,937	↓
FS_V	3.98	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	8.4	48.8	57.2	5,309
Total	8.4	48.8	57.2	5,309

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.10	0.73	1.10	0.22	1.64	187

Horizontal Force Balance

F_D (lbf)	187	→
F_P (lbf)	12,781	←
F_F (lbf)	4,292	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	16,885	←
FS_H	91.17	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	306
Bank	4.81	12,781	26.02	0.87	3,985
Total	-	12,781	28.02	-	4,292

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	26.6	27.1	16.6	12.0	13.0	16.0

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	32,597
M_r (lbf)	406,394
FS_M	12.47 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
						Applied Forces from other Logs		
Header	Above	Gravity	10.0	-397	-3,050	397	↓	0
								0
								0
								0

Lapwai Creek Reach 14

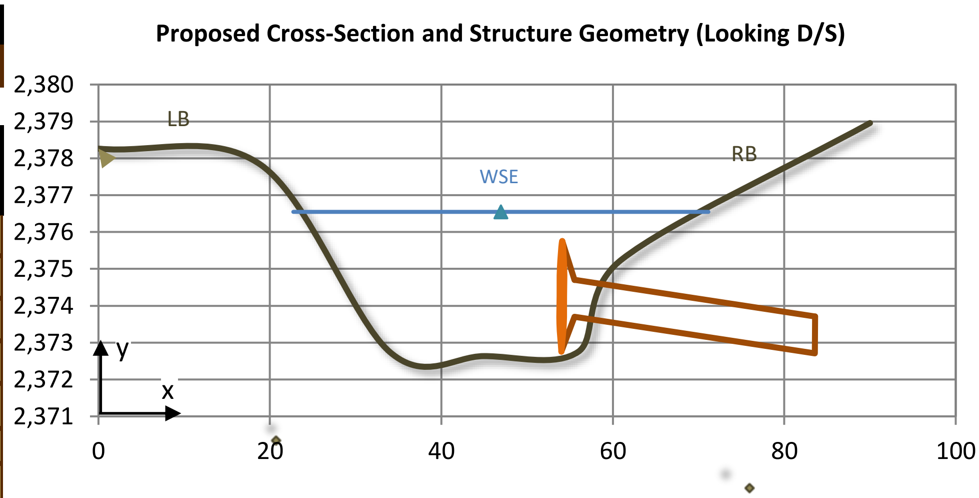
Spreadsheet developed by Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type A	Rootwad	Right bank	Straight	8+50	3.91	31.25	4.11

Multi-Log Structures	Layer	Log ID
	N/A	RW#3

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,378.3
Top LB	19.0	2,377.8
Toe LB	34.0	2,372.7
Thalweg	45.0	2,372.6
Toe RB	56.0	2,372.8
Top RB	61.0	2,375.2
Fldpln RB	90.0	2,379.0

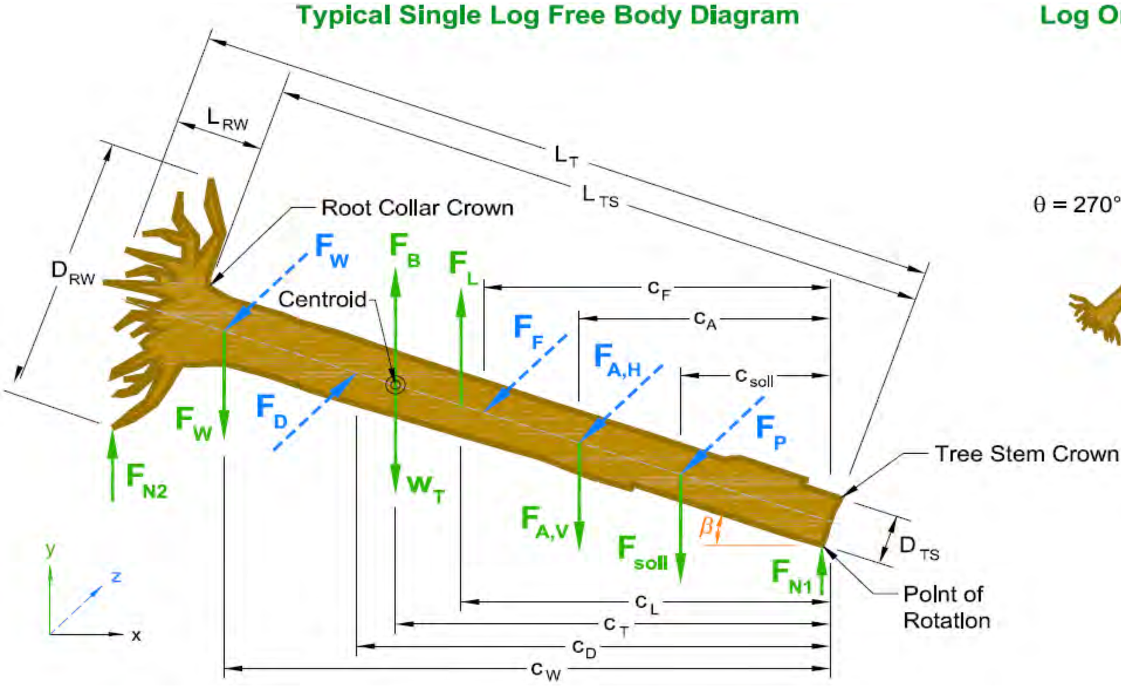


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

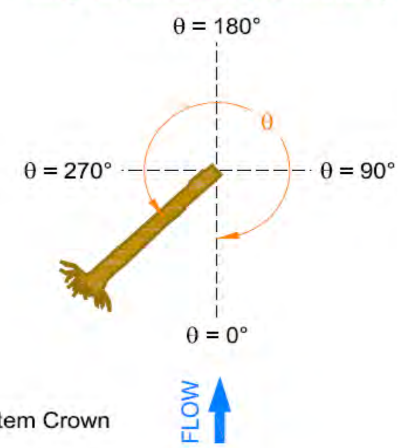
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	260.0	-2.0	Rootwad: Bottom	54.00	2,372.76	2,372.71	2,375.76	5.78

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	24.36	4.43	2.46

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.4	4.1	26.5	888	1,652
↓Thalweg	0.0	0.0	0.0	0	0
Total	22.4	4.1	26.5	888	1,652

Lift Force

C_{LT}	0.03
F_L (lbf)	3

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	3	↑
W_T (lbf)	888	↓
F_{soil} (lbf)	5,624	↓
$F_{W,V}$ (lbf)	397	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	5,253	↓
FS_V	4.17	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	10.1	49.8	59.8	5,624
Total	10.1	49.8	59.8	5,624

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.08	0.73	1.10	0.22	1.58	150

Horizontal Force Balance

F_D (lbf)	150	→
F_P (lbf)	13,539	←
F_F (lbf)	4,567	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	17,956	←
FS_H	120.97	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	322
Bank	4.81	13,539	26.32	0.87	4,244
Total	-	13,539	28.32	-	4,567

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	26.8	27.2	16.6	12.2	13.1	16.2

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	31,556
M_r (lbf)	434,986
FS_M	13.78 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs: $F_{W,V}$ (lbf)		Applied Forces from other Logs: $F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-397	-3,050	397	↓	0
								0
								0
								0

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

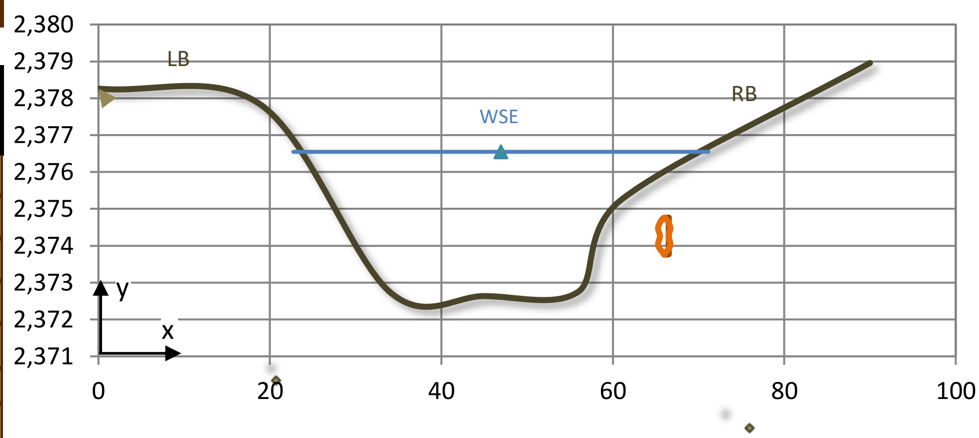
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type A	Log Vane	Right bank	Straight	8+50	3.91	31.25	4.11

Multi-Log Structures	Layer	Log ID
	N/A	Header

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,378.3
Top LB	19.0	2,377.8
Toe LB	34.0	2,372.7
Thalweg	45.0	2,372.6
Toe RB	56.0	2,372.8
Top RB	61.0	2,375.2
Fldpln RB	90.0	2,379.0

Proposed Cross-Section and Structure Geometry (Looking D/S)

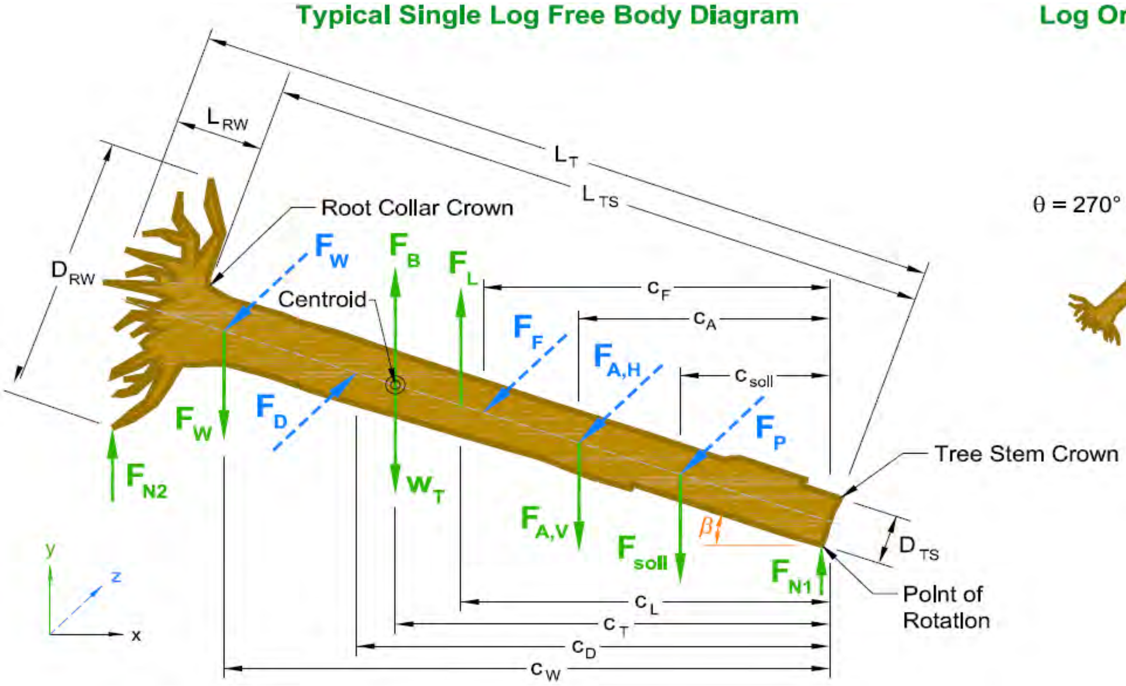


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.00	-	-	33.5	38.0

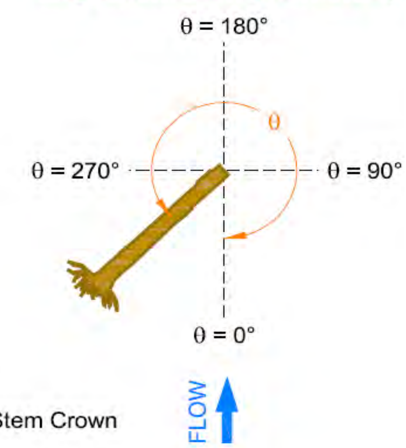
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	181.0	0.0	Root collar: Bottom	66.00	2,373.76	2,373.76	2,374.76	0.00

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	30.00	1.19	1.16

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft³)	V_{RW} (ft³)	V_T (ft³)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	23.6	0.0	23.6	790	1,470
↓Thalweg	0.0	0.0	0.0	0	0
Total	23.6	0.0	23.6	790	1,470

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	1,470	↑
F_L (lbf)	0	
W_T (lbf)	790	↓
F_{soil} (lbf)	2,973	↓
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	2,293	↓
FS_V	2.56	✓

Soil Ballast Force

Soil	V_{dry} (ft³)	V_{sat} (ft³)	V_{soil} (ft³)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	34.8	34.8	2,973
Total	0.0	34.8	34.8	2,973

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.00	0.73	1.07	0.00	1.06	0

Horizontal Force Balance

F_D (lbf)	0	
F_P (lbf)	7,156	←
F_F (lbf)	1,993	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	9,149	←
FS_H	18,302.38	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	125
Bank	4.81	7,156	30.00	0.87	1,868
Total	-	7,156	32.00	-	1,993

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	0.0	0.0	15.0	15.0	15.0	15.0

*Distances are from the stem tip

Point of Rotation: Root Collar

Moment Force Balance

M_d (lbf)	22,069	
M_r (lbf)	228,075	
FS_M	10.33	✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft³)	V_{Awet} (ft³)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft³)	$V_{r,wet}$ (ft³)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

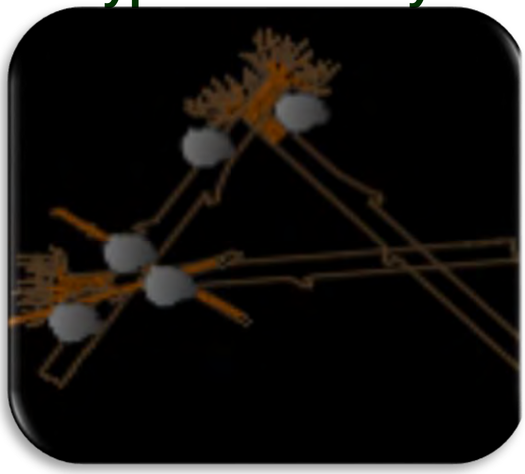
Interaction Forces with Adjacent Logs

Applied Forces from other Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type B Stability Analysis



Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

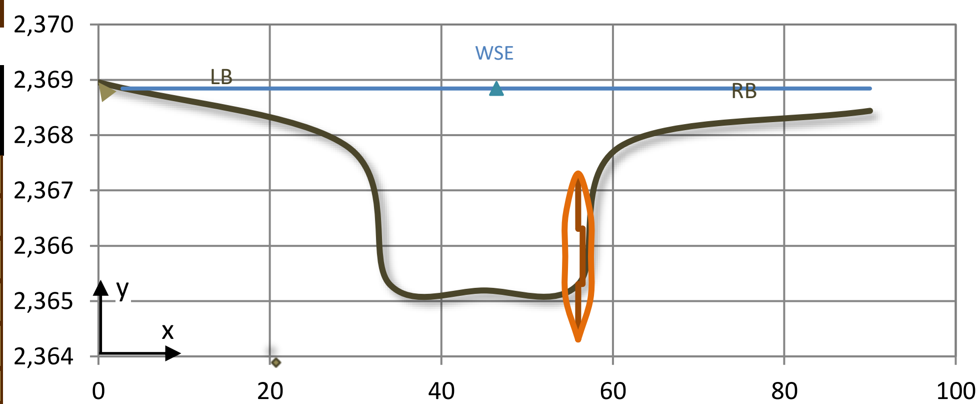
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type B	Rootwad	Right bank	Straight	6+00	3.65	31.25	3.33

Multi-Log Structures	Layer	Log ID
	Footer	Footer

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,369.0
Top LB	29.0	2,367.8
Toe LB	34.0	2,365.3
Thalweg	45.0	2,365.2
Toe RB	56.0	2,365.3
Top RB	61.0	2,367.8
Fldpln RB	90.0	2,368.4

Proposed Cross-Section and Structure Geometry (Looking D/S)

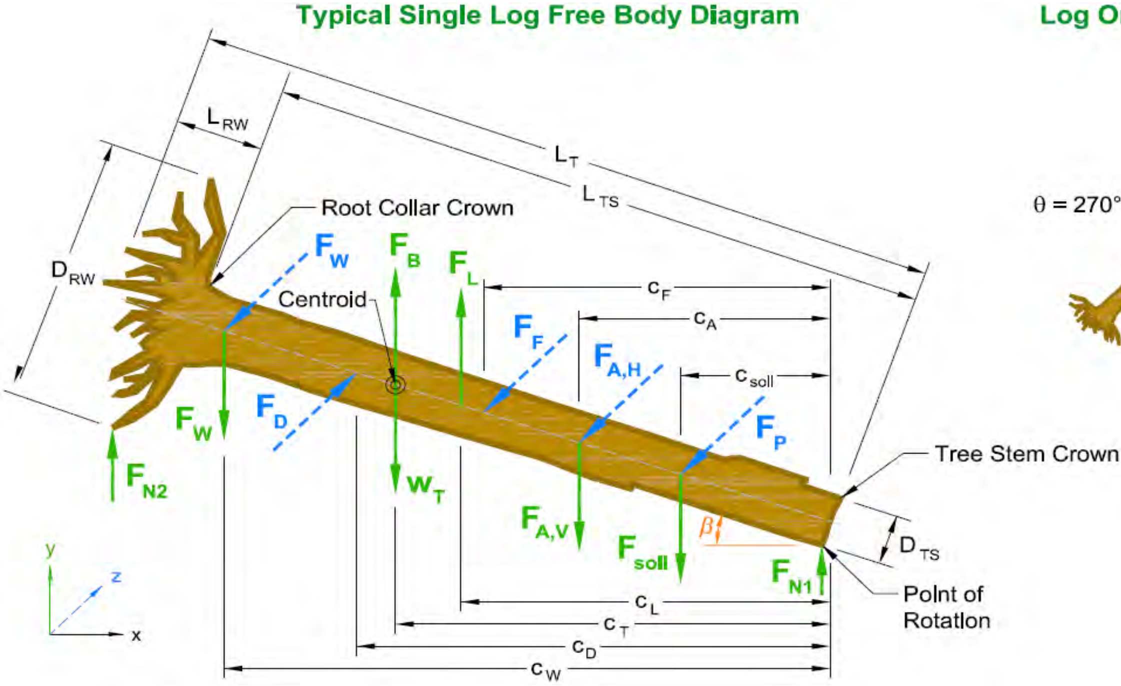


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

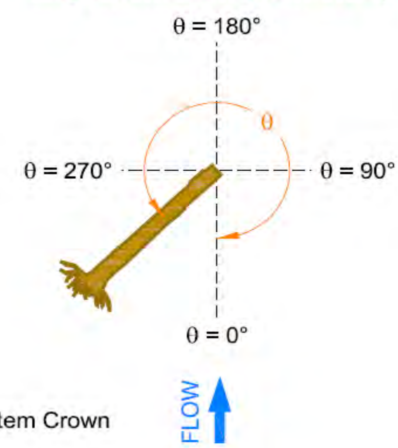
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	359.0	0.0	Root collar: Bottom	55.98	2,365.31	2,364.31	2,367.31	5.78

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	0.00	0.00	0.00

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.4	3.4	25.8	865	1,609
↓Thalweg	0.0	0.7	0.7	26	43
Total	22.4	4.1	26.5	891	1,652

Lift Force

C_{LT}	0.02
F_L (lbf)	2

Vertical Force Balance

F_B (lbf)	1,652
F_L (lbf)	2
W_T (lbf)	891
F_{soil} (lbf)	0
$F_{W,V}$ (lbf)	3,477
$F_{A,V}$ (lbf)	0
ΣF_V (lbf)	2,715
FS_V	2.64

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	0.0	0.0	0
Total	0.0	0.0	0.0	0

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_W	C_D*	F_D (lbf)
0.08	0.59	1.10	0.09	1.43	89

Horizontal Force Balance

F_D (lbf)	89
F_P (lbf)	0
F_F (lbf)	2,360
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
ΣF_H (lbf)	2,271
FS_H	26.55

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	155
Bank	4.81	0	28.42	0.87	2,205
Total	-	0	30.42	-	2,360

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	29.3	15.0	16.6	0.0	14.2	0.0

*Distances are from the stem tip

Point of Rotation: Rootwad

Moment Force Balance

M_d (lbf)	23,393
M_r (lbf)	130,577
FS_M	5.58

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs: $F_{W,V}$ (lbf)		Applied Forces from other Logs: $F_{W,H}$ (lbf)
Top #1	Above	Gravity	15.0	-1,021	-9,137	1,021	↓	0
Top #2	Above	Gravity	25.0	-1,021	-9,137	1,021	↓	0
Top #3	Above	Gravity	17.5	-1,435	-9,879	1,435	↓	0
						0		0

Lapwai Creek Reach 14

Spreadsheet developed by Michael Rafferty, P.E.

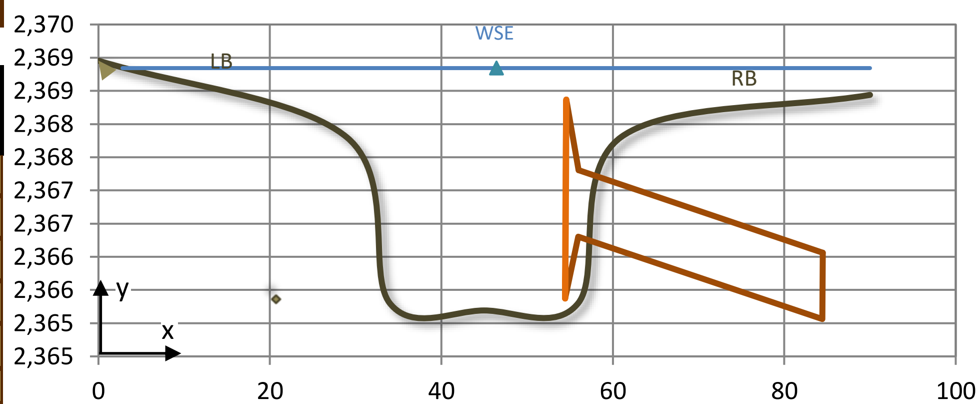
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type B	Rootwad	Right bank	Straight	6+00	3.65	31.25	3.33

Multi-Log Structures	Layer	Log ID
	Stacked	Top #1

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,369.0
Top LB	29.0	2,367.8
Toe LB	34.0	2,365.3
Thalweg	45.0	2,365.2
Toe RB	56.0	2,365.3
Top RB	61.0	2,367.8
Fldpln RB	90.0	2,368.4

Proposed Cross-Section and Structure Geometry (Looking D/S)



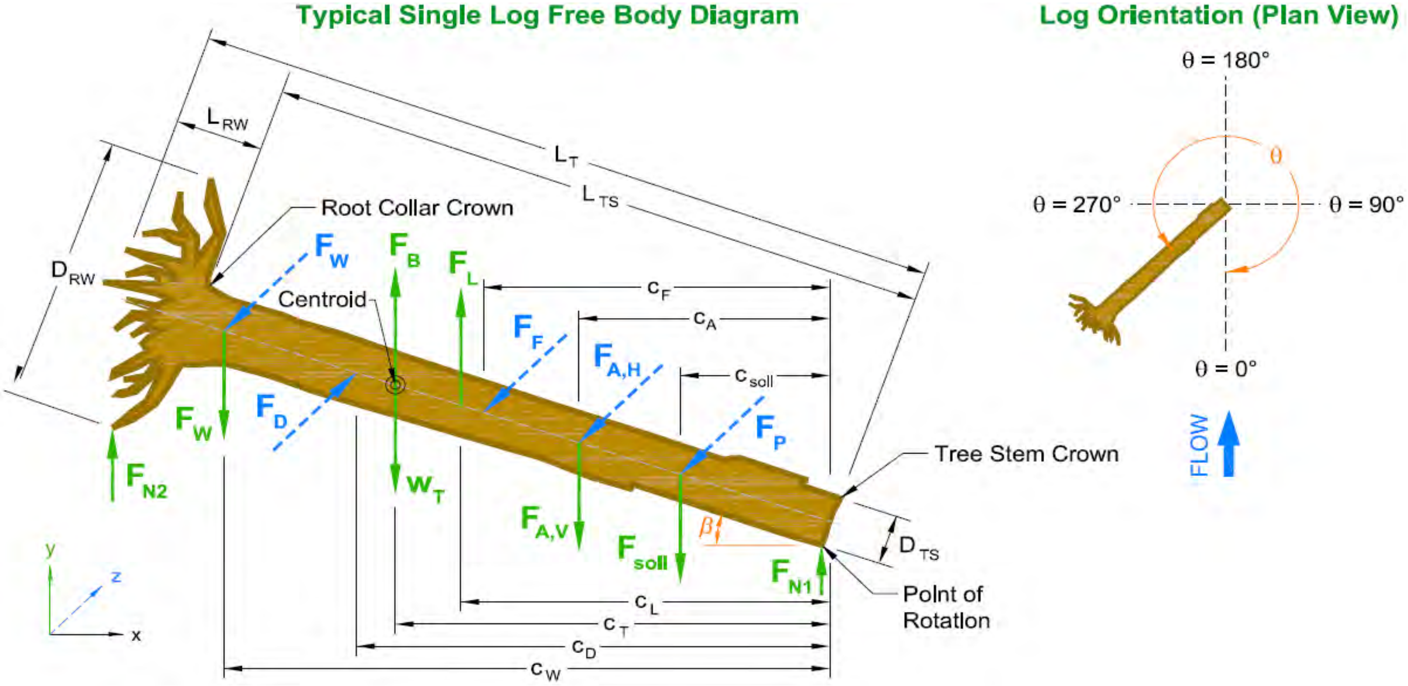
Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	271.0	-2.5	Root collar: Bottom	55.98	2,366.31	2,365.06	2,368.37	4.29

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	24.86	2.26	1.43

Typical Single Log Free Body Diagram

Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.3	4.1	26.4	885	1,647
↓Thalweg	0.1	0.0	0.1	3	4
Total	22.4	4.1	26.5	888	1,652

Lift Force

C_{LT}	0.05
F_L (lbf)	2

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	2	↑
W_T (lbf)	888	↓
F_{soil} (lbf)	3,027	↓
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
ΣF_V (lbf)	2,261	↓
FS_V	2.37	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	35.5	35.5	3,027
Total	0.0	35.5	35.5	3,027

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.06	0.59	1.10	0.37	1.67	77

Horizontal Force Balance

F_D (lbf)	77	→
F_P (lbf)	7,287	←
F_F (lbf)	1,966	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
ΣF_H (lbf)	9,175	←
FS_H	119.53	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	137
Bank	4.81	7,287	26.62	0.87	1,828
Total	-	7,287	28.62	-	1,966

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	27.2	27.5	16.6	12.4	13.3	16.5

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	29,570	
M_r (lbf)	228,337	
FS_M	7.72	✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs $F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

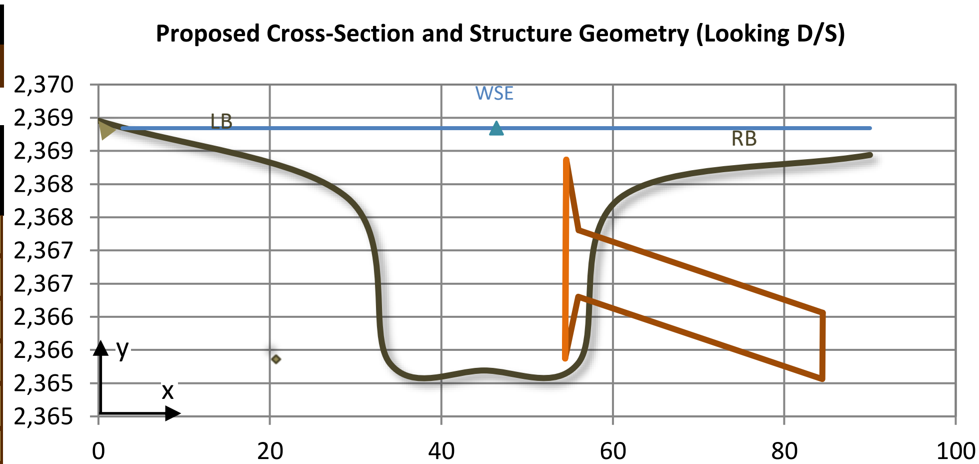
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type B	Rootwad	Right bank	Straight	6+00	3.65	31.25	3.33

Multi-Log Structures	Layer	Log ID
	Stacked	Top #2

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,369.0
Top LB	29.0	2,367.8
Toe LB	34.0	2,365.3
Thalweg	45.0	2,365.2
Toe RB	56.0	2,365.3
Top RB	61.0	2,367.8
Fldpln RB	90.0	2,368.4

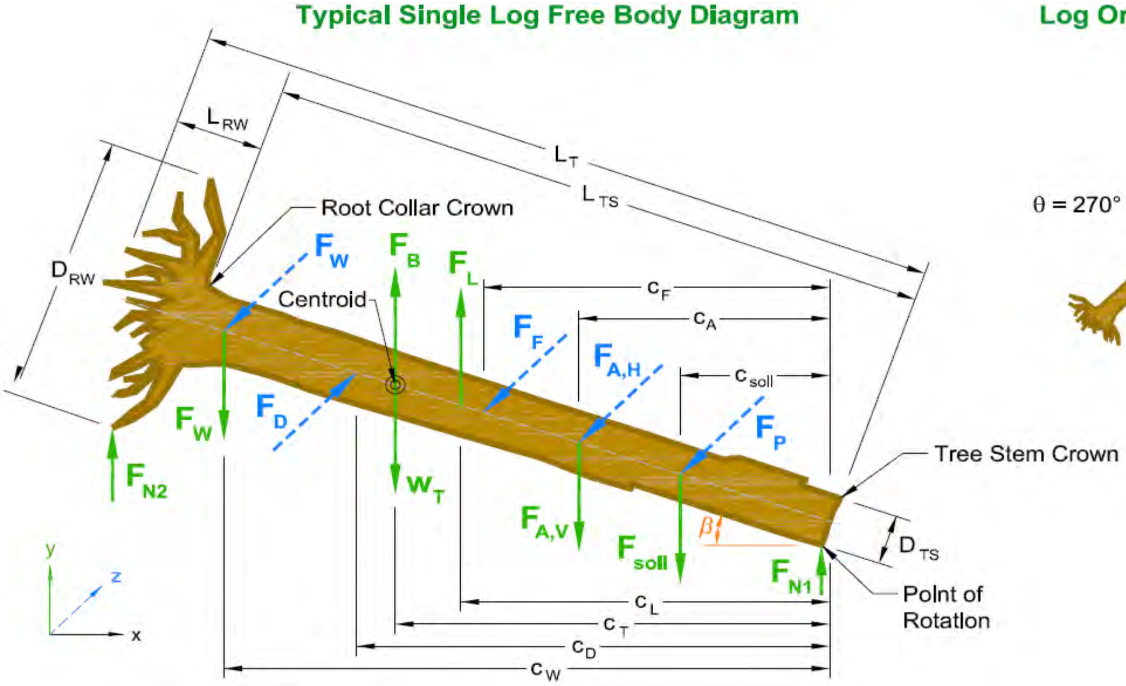


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

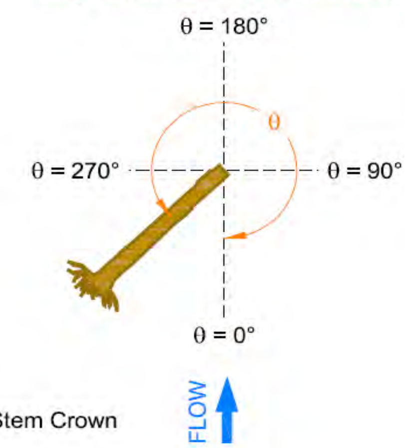
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	271.0	-2.5	Root collar: Bottom	55.98	2,366.31	2,365.06	2,368.37	4.29

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	24.86	2.26	1.43

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Type B Rootwad Stacked Log ID Top #2

Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	22.3	4.1	26.4	885	1,647
↓Thalweg	0.1	0.0	0.1	3	4
Total	22.4	4.1	26.5	888	1,652

Lift Force

C_{LT}	0.05
F_L (lbf)	2

Vertical Force Balance

F_B (lbf)	1,652
F_L (lbf)	2
W_T (lbf)	888
F_{soil} (lbf)	3,027
$F_{W,V}$ (lbf)	0
$F_{A,V}$ (lbf)	0
Σ F_V (lbf)	2,261
FS_V	2.37

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	35.5	35.5	3,027
Total	0.0	35.5	35.5	3,027

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.06	0.59	1.10	0.37	1.67	77

Horizontal Force Balance

F_D (lbf)	77
F_P (lbf)	7,287
F_F (lbf)	1,966
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
Σ F_H (lbf)	9,175
FS_H	119.53

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	137
Bank	4.81	7,287	26.62	0.87	1,828
Total	-	7,287	28.62	-	1,966

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	27.2	27.5	16.6	12.4	13.3	16.5

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	29,570
M_r (lbf)	228,337
FS_M	7.72

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs $F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

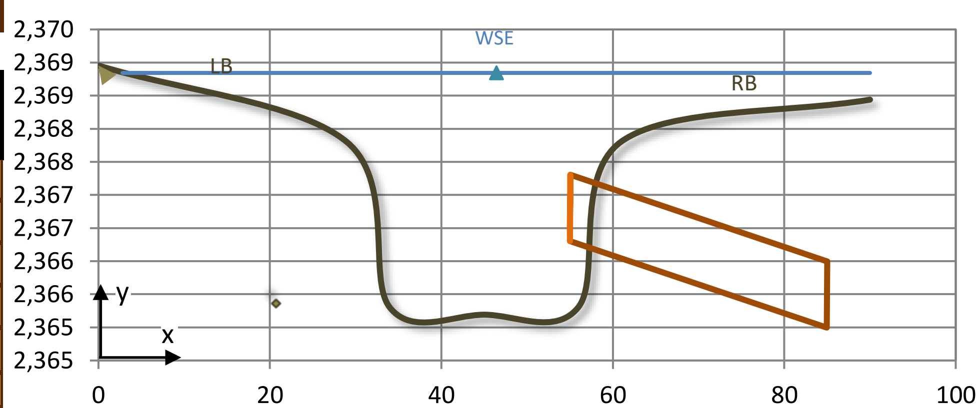
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type B	Log Vane	Right bank	Straight	6+00	3.65	31.25	3.33

Multi-Log Structures	Layer	Log ID
	Stacked	Top #3

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,369.0
Top LB	29.0	2,367.8
Toe LB	34.0	2,365.3
Thalweg	45.0	2,365.2
Toe RB	56.0	2,365.3
Top RB	61.0	2,367.8
Fldpln RB	90.0	2,368.4

Proposed Cross-Section and Structure Geometry (Looking D/S)

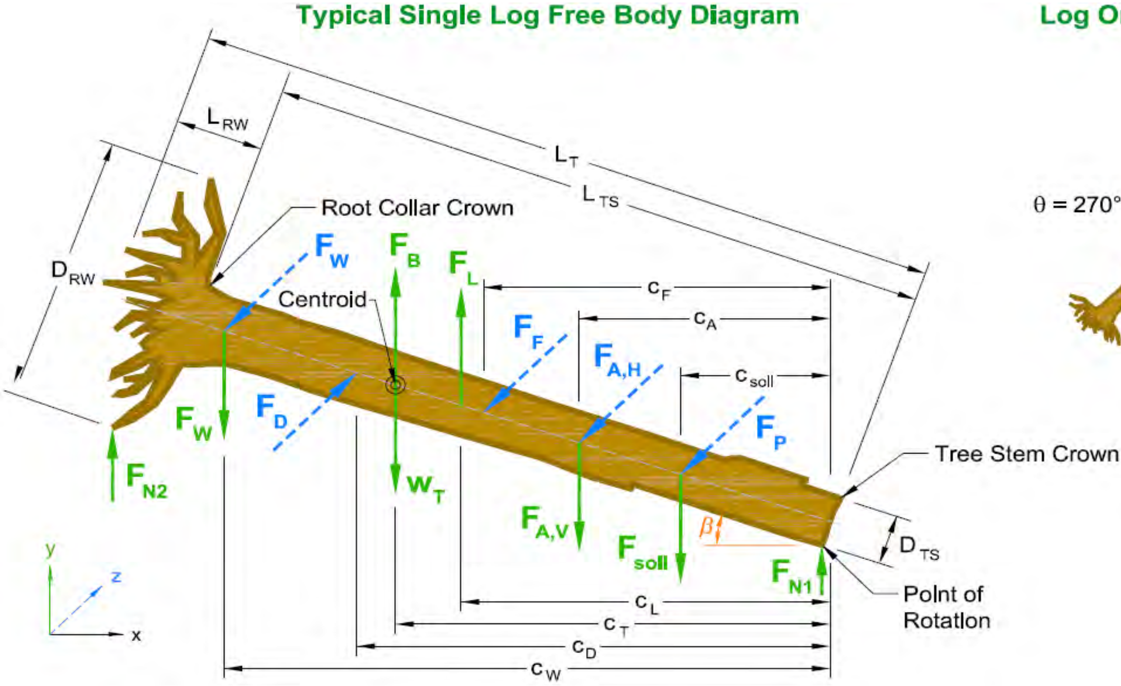


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.00	-	-	33.5	38.0

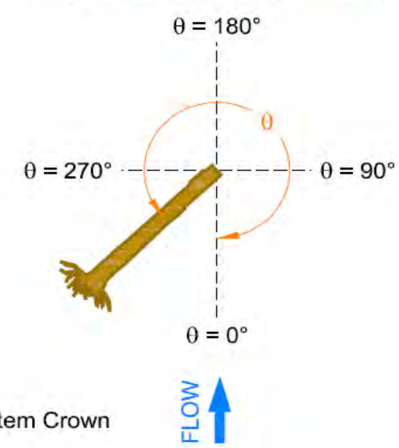
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	271.0	-2.5	Root collar: Bottom	55.00	2,366.31	2,365.00	2,367.30	3.57

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	φ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	25.46	2.33	1.49

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	23.4	0.0	23.4	784	1,458
↓Thalweg	0.2	0.0	0.2	7	12
Total	23.6	0.0	23.6	791	1,470

Lift Force

C_{LT}	0.05
F_L (lbf)	2

Vertical Force Balance

F_B (lbf)	1,470	↑
F_L (lbf)	2	↑
W_T (lbf)	791	↓
F_{soil} (lbf)	3,220	↓
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	2,539	↓
FS_V	2.72	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	37.8	37.8	3,220
Total	0.0	37.8	37.8	3,220

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.05	0.59	0.93	0.34	1.41	54

Horizontal Force Balance

F_D (lbf)	54	→
F_P (lbf)	7,753	←
F_F (lbf)	2,207	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	9,906	←
FS_H	183.16	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	151
Bank	4.81	7,753	27.22	0.87	2,056
Total	-	7,753	29.22	-	2,207

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	27.8	27.8	15.0	12.7	13.6	16.9

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	23,596
M_r (lbf)	247,910
FS_M	10.51 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs	
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type C Stability Analysis

Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

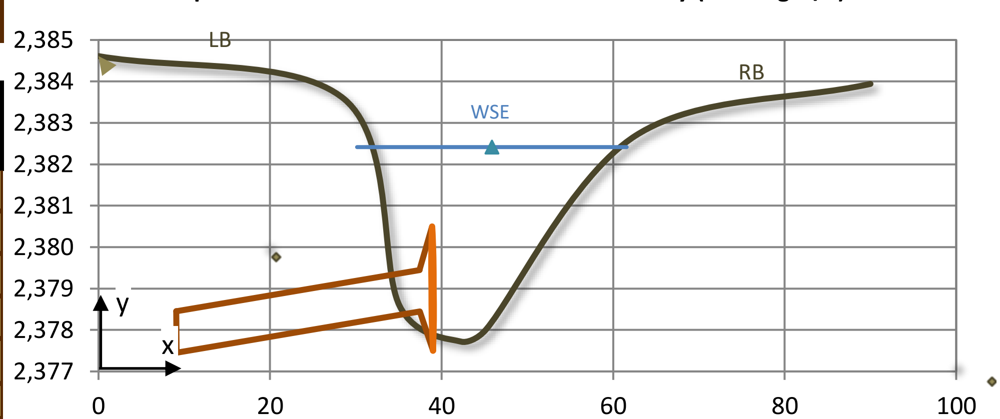
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Rootwad	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	RW#1

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

Proposed Cross-Section and Structure Geometry (Looking D/S)

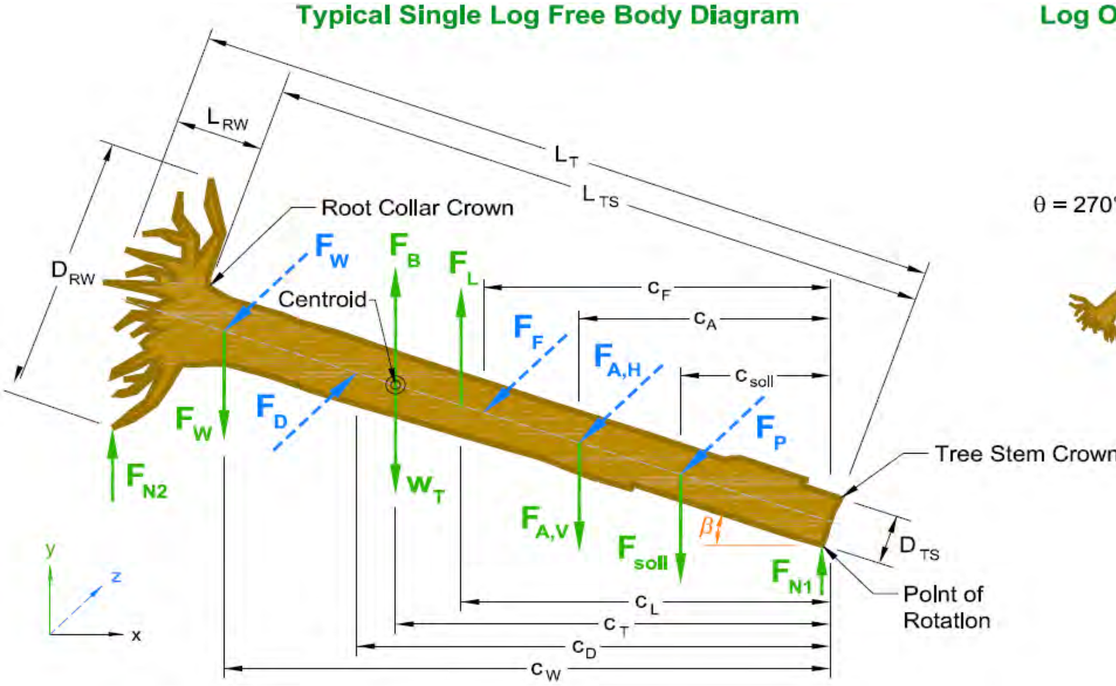


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

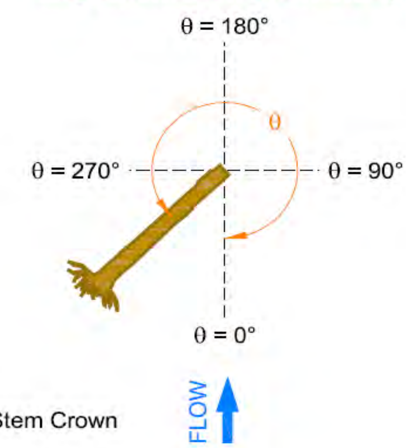
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	95.0	-2.0	Rootwad: Bottom	39.00	2,377.50	2,377.45	2,380.50	4.59

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	25.18	5.83	4.51

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	21.9	4.1	25.9	870	1,618
↓Thalweg	0.5	0.0	0.5	21	34
Total	22.4	4.1	26.5	890	1,652

Lift Force

C_{LT}	0.15
F_L (lbf)	23

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	23	↑
W_T (lbf)	890	↓
F_{soil} (lbf)	11,238	↓
$F_{W,V}$ (lbf)	2,072	↓
$F_{A,V}$ (lbf)	0	
ΣF_V (lbf)	12,525	↓
FS_V	8.48	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	30.6	82.5	113.2	11,238
Total	30.6	82.5	113.2	11,238

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.07	1.05	0.98	0.05	1.18	186

Horizontal Force Balance

F_D (lbf)	186	→
F_P (lbf)	27,054	←
F_F (lbf)	10,888	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
ΣF_H (lbf)	37,757	←
FS_H	204.39	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	3.35	0.87	1,235
Bank	4.81	27,054	26.17	0.87	9,653
Total	-	27,054	29.52	-	10,888

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	28.8	27.6	16.6	12.5	13.7	16.7

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	33,173
M_r (lbf)	948,822
FS_M	28.60 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Applied Forces from other Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-2,072	-7,838	2,072 ↓	0
							0
							0
							0

Lapwai Creek Reach 14

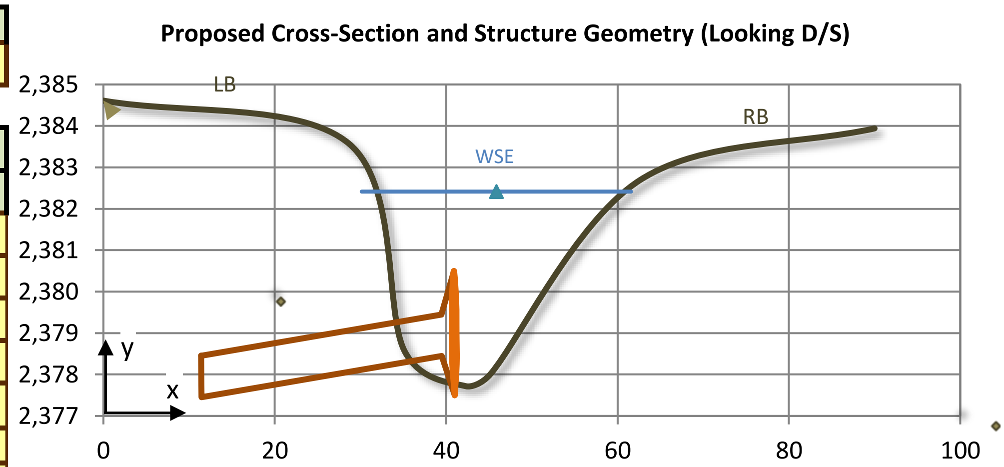
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Rootwad	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	RW#2

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

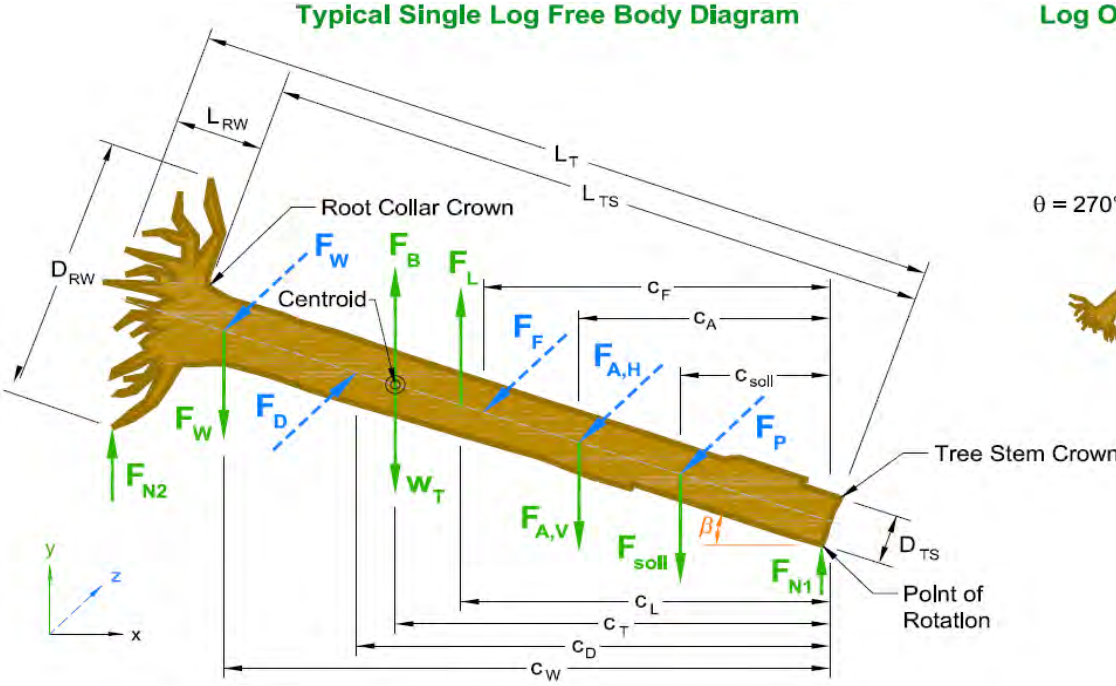


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

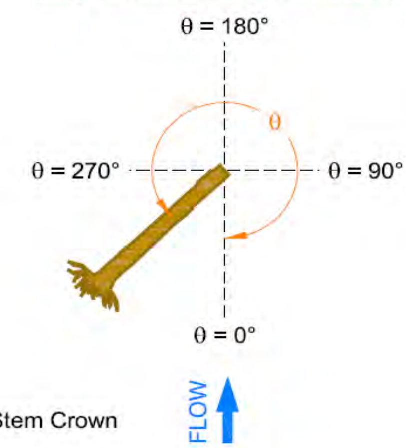
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	100.0	-2.0	Rootwad: Bottom	41.00	2,377.50	2,377.45	2,380.50	7.00

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	23.18	5.75	4.43

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft³)	V_{RW} (ft³)	V_T (ft³)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	21.9	4.1	25.9	870	1,618
↓Thalweg	0.5	0.0	0.5	21	34
Total	22.4	4.1	26.5	890	1,652

Lift Force

C_{LT}	0.10
F_L (lbf)	25

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	25	↑
W_T (lbf)	890	↓
F_{soil} (lbf)	10,129	↓
$F_{W,V}$ (lbf)	2,072	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	11,415	↓
FS_V	7.81	✓

Soil Ballast Force

Soil	V_{dry} (ft³)	V_{sat} (ft³)	V_{soil} (ft³)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	26.6	76.0	102.6	10,129
Total	26.6	76.0	102.6	10,129

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.10	1.05	0.98	0.05	1.28	308

Horizontal Force Balance

F_D (lbf)	308	→
F_P (lbf)	24,386	←
F_F (lbf)	9,923	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	34,001	←
FS_H	111.44	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	3.95	0.87	1,399
Bank	4.81	24,386	24.07	0.87	8,524
Total	-	24,386	28.02	-	9,923

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	27.7	26.6	16.6	11.6	13.0	15.4

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	36,281
M_r (lbf)	804,399
FS_M	22.17 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft³)	V_{Awet} (ft³)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft³)	$V_{r,wet}$ (ft³)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs		
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-2,072	-7,838	2,072	↓	0
								0
								0
								0

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

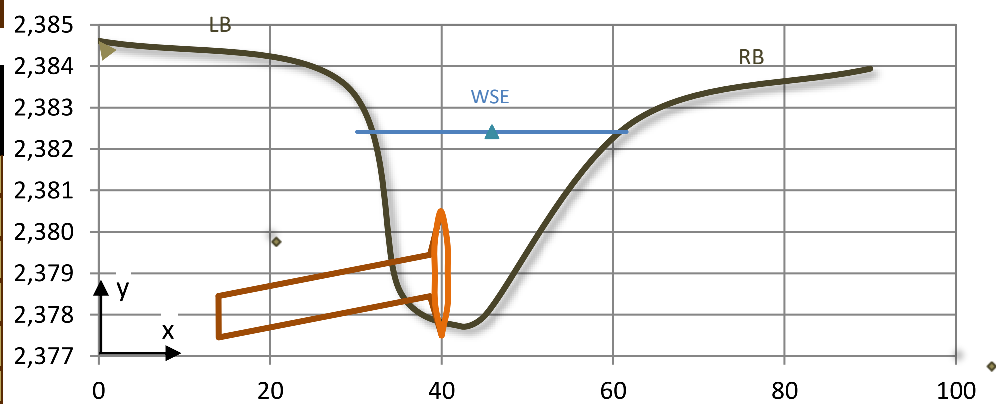
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Rootwad	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	RW#3

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

Proposed Cross-Section and Structure Geometry (Looking D/S)

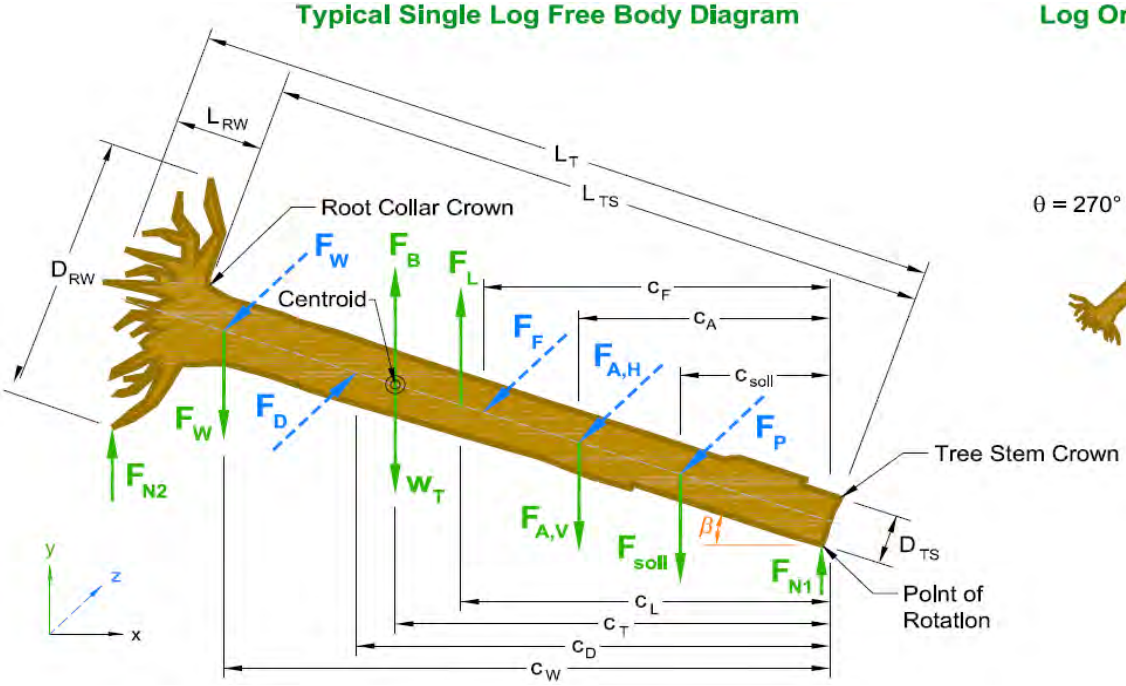


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

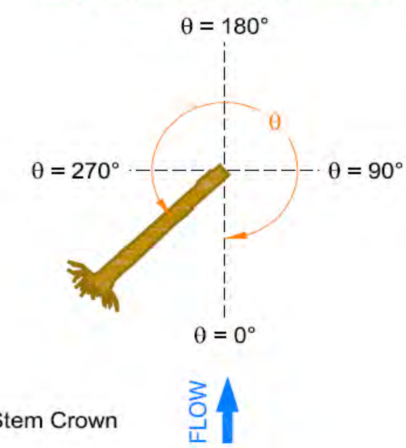
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	120.0	-2.0	Rootwad: Bottom	40.00	2,377.50	2,377.45	2,380.50	8.28

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	23.38	5.65	4.33

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	21.9	4.1	25.9	870	1,618
↓Thalweg	0.5	0.0	0.5	21	34
Total	22.4	4.1	26.5	890	1,652

Lift Force

C_{LT}	0.12
F_L (lbf)	34

Vertical Force Balance

F_B (lbf)	1,652
F_L (lbf)	34
W_T (lbf)	890
F_{soil} (lbf)	9,904
$F_{W,V}$ (lbf)	2,072
$F_{A,V}$ (lbf)	0
Σ F_V (lbf)	11,181
FS_V	7.63

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	25.2	75.7	100.9	9,904
Total	25.2	75.7	100.9	9,904

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.12	1.05	0.94	0.05	1.28	363

Horizontal Force Balance

F_D (lbf)	363
F_P (lbf)	23,844
F_F (lbf)	9,720
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
Σ F_H (lbf)	33,200
FS_H	92.39

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	4.10	0.87	1,399
Bank	4.81	23,844	24.37	0.87	8,320
Total	-	23,844	28.47	-	9,720

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	28.3	26.7	16.6	11.6	13.2	15.5

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	38,036
M_r (lbf)	795,617
FS_M	20.92

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs	
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-2,072	-7,838	2,072	0
							0
							0
							0

Lapwai Creek Reach 14

Spreadsheet developed by Michael Rafferty, P.E.

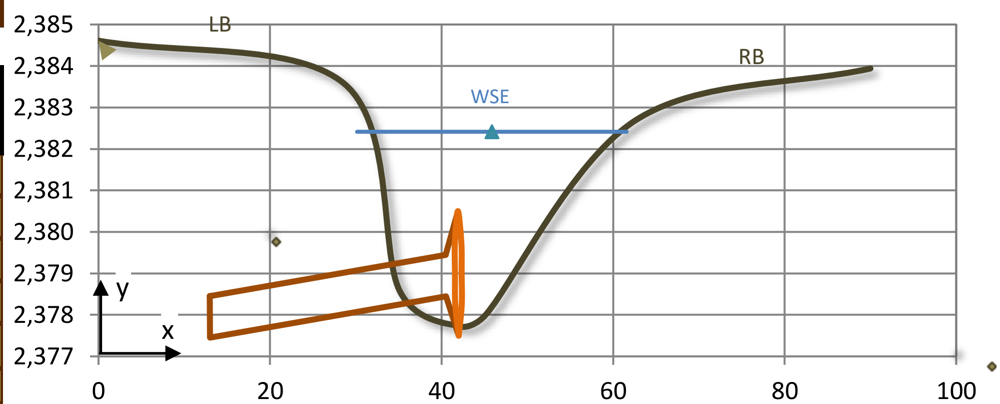
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Rootwad	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	RW#4

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

Proposed Cross-Section and Structure Geometry (Looking D/S)

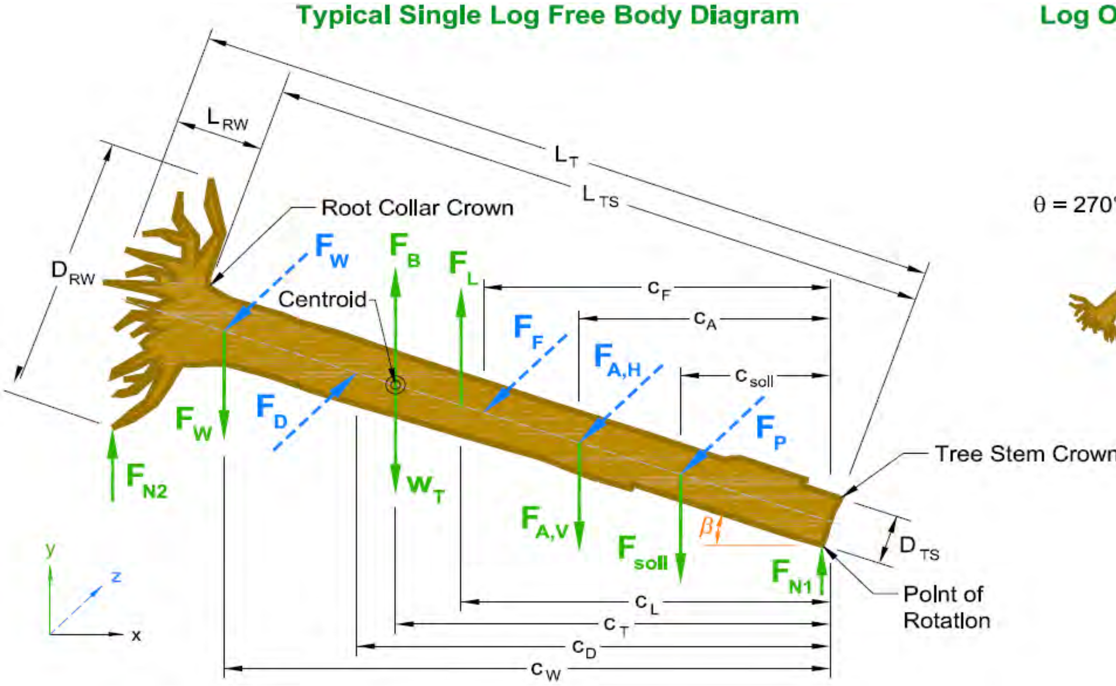


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

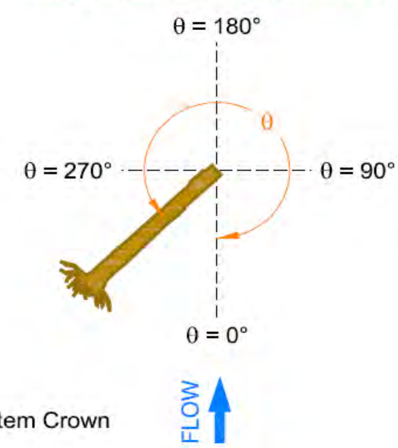
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	75.0	-2.0	Rootwad: Bottom	42.00	2,377.50	2,377.45	2,380.50	8.47

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	22.06	5.69	4.36

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft³)	V_{RW} (ft³)	V_T (ft³)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	21.9	4.1	25.9	870	1,618
↓Thalweg	0.5	0.0	0.5	21	34
Total	22.4	4.1	26.5	890	1,652

Lift Force

C_{LT}	0.09
F_L (lbf)	28

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	28	↑
W_T (lbf)	890	↓
F_{soil} (lbf)	9,483	↓
$F_{W,V}$ (lbf)	2,072	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	10,766	↓
FS_V	7.41	✓

Soil Ballast Force

Soil	V_{dry} (ft³)	V_{sat} (ft³)	V_{soil} (ft³)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	24.3	72.1	96.4	9,483
Total	24.3	72.1	96.4	9,483

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.12	1.05	1.14	0.05	1.55	450

Horizontal Force Balance

F_D (lbf)	450	→
F_P (lbf)	22,829	←
F_F (lbf)	9,358	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	31,738	←
FS_H	71.59	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	4.25	0.87	1,466
Bank	4.81	22,829	22.88	0.87	7,892
Total	-	22,829	27.13	-	9,358

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	26.8	26.1	16.6	11.0	12.5	14.7

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	39,857	
M_r (lbf)	727,241	
FS_M	18.25	✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft³)	V_{Awet} (ft³)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft³)	$V_{r,wet}$ (ft³)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs	
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-2,072	-7,838	2,072	0
							0
							0
							0

Lapwai Creek Reach 14

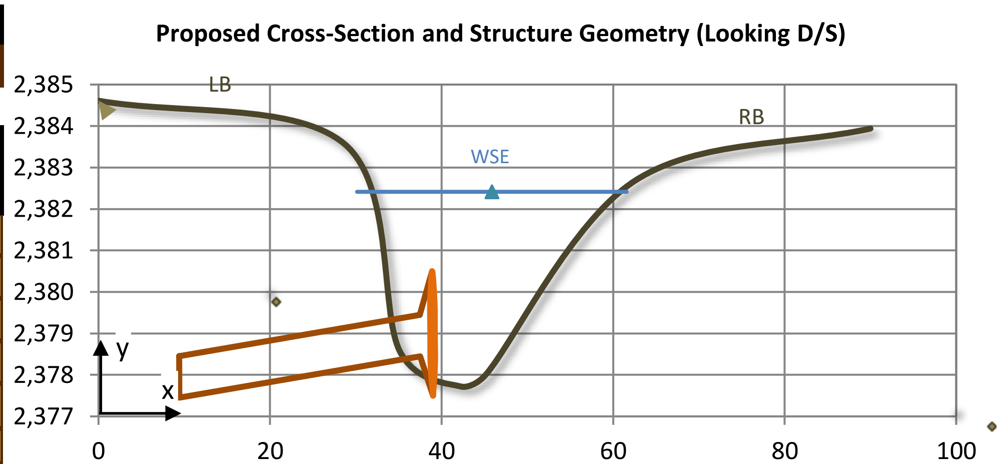
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Rootwad	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	RW#5

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

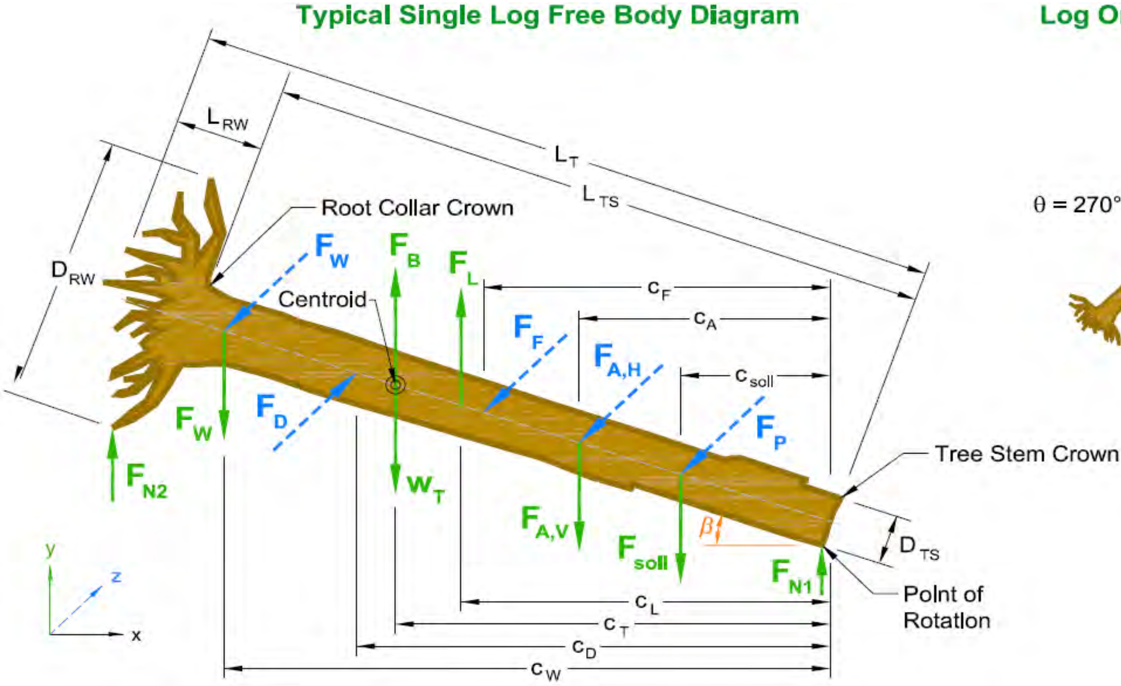


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

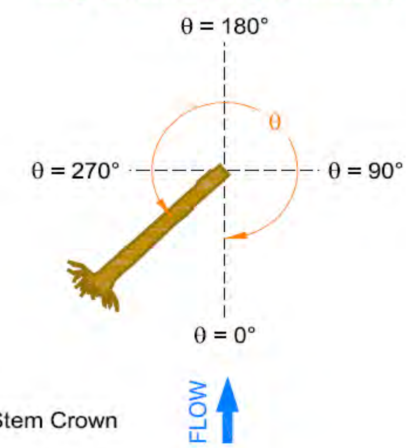
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	80.0	-2.0	Rootwad: Bottom	39.00	2,377.50	2,377.45	2,380.50	5.18

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	φ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	25.12	5.82	4.49

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft³)	V_{RW} (ft³)	V_T (ft³)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	21.9	4.1	25.9	870	1,618
↓Thalweg	0.5	0.0	0.5	21	34
Total	22.4	4.1	26.5	890	1,652

Lift Force

C_{LT}	0.14
F_L (lbf)	26

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	26	↑
W_T (lbf)	890	↓
F_{soil} (lbf)	11,177	↓
$F_{W,V}$ (lbf)	2,072	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	12,461	↓
FS_V	8.43	✓

Soil Ballast Force

Soil	V_{dry} (ft³)	V_{sat} (ft³)	V_{soil} (ft³)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	30.3	82.3	112.6	11,177
Total	30.3	82.3	112.6	11,177

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.08	1.05	1.08	0.05	1.32	235

Horizontal Force Balance

F_D (lbf)	235	→
F_P (lbf)	26,907	←
F_F (lbf)	10,832	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	37,504	←
FS_H	160.34	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	3.50	0.87	1,284
Bank	4.81	26,907	26.02	0.87	9,548
Total	-	26,907	29.52	-	10,832

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	28.8	27.6	16.6	12.5	13.7	16.7

*Distances are from the stem tip

Point of Rotation:	Stem Tip

Moment Force Balance

M_d (lbf)	34,626
M_r (lbf)	943,965
FS_M	27.26 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft³)	V_{Awet} (ft³)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft³)	$V_{r,wet}$ (ft³)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs $F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
Header	Above	Gravity	10.0	-2,072	-7,838	2,072	↓	0
								0
								0
								0

Lapwai Creek Reach 14

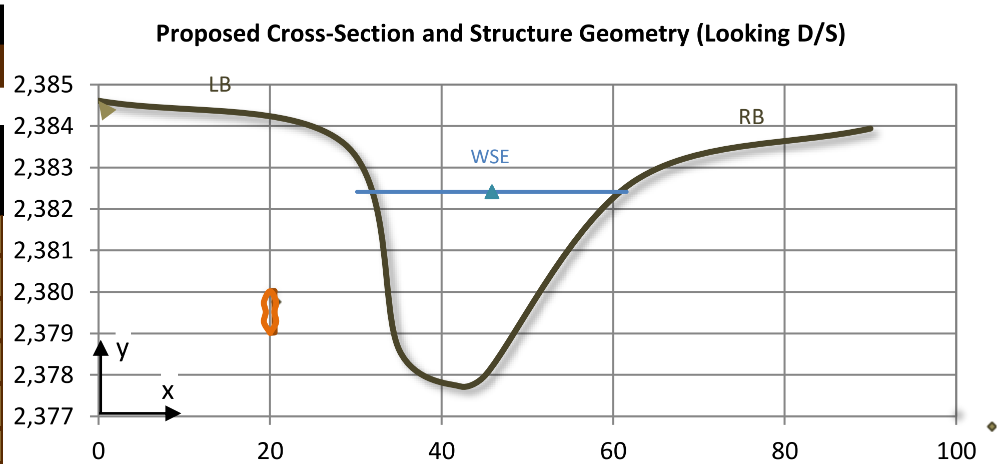
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type C	Log Vane	Left bank	Straight	10+25	4.70	31.25	5.95

Multi-Log Structures	Layer	Log ID
	N/A	Header

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	28.6	2,383.6
Toe LB	35.1	2,378.6
Thalweg	42.3	2,377.7
Toe RB	45.2	2,378.0
Top RB	62.6	2,382.7
Fldpln RB	90.0	2,383.9

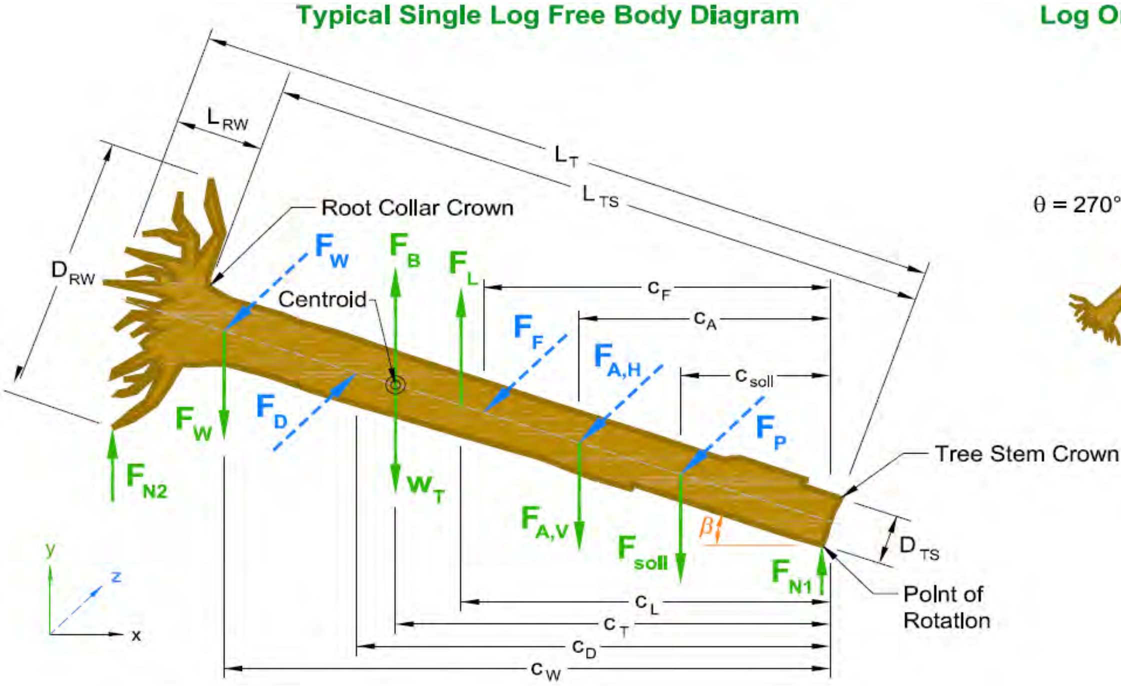


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.00	-	-	33.5	38.0

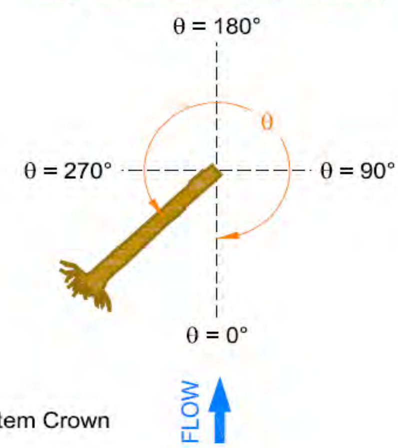
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	181.0	0.0	Root collar: Bottom	20.00	2,379.02	2,379.02	2,380.02	0.00

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	30.00	3.87	3.86

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	23.6	0.0	23.6	790	1,470
↓Thalweg	0.0	0.0	0.0	0	0
Total	23.6	0.0	23.6	790	1,470

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	1,470
F_L (lbf)	0
W_T (lbf)	790
F_{soil} (lbf)	12,141
$F_{W,V}$ (lbf)	0
$F_{A,V}$ (lbf)	0
ΣF_V (lbf)	11,461
FS_V	8.80

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	43.9	71.9	115.7	12,141
Total	43.9	71.9	115.7	12,141

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.00	1.05	1.07	0.00	1.06	0

Horizontal Force Balance

F_D (lbf)	0
F_P (lbf)	29,230
F_F (lbf)	9,963
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
ΣF_H (lbf)	39,193
FS_H	78,401.70

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	623
Bank	4.81	29,230	30.00	0.87	9,341
Total	-	29,230	32.00	-	9,963

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	0.0	0.0	15.0	15.0	15.0	15.0

*Distances are from the stem tip

Point of Rotation: Root Collar

Moment Force Balance

M_d (lbf)	22,069
M_r (lbf)	953,791
FS_M	43.22

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

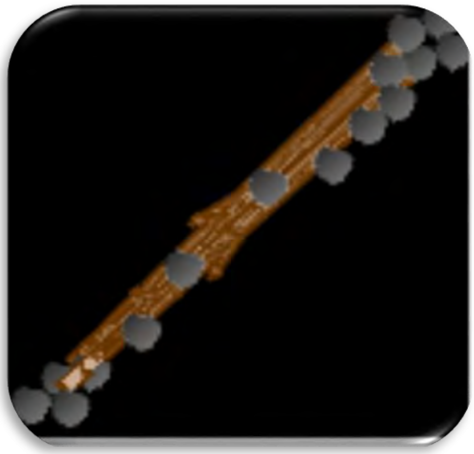
Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs: $F_{W,V}$ (lbf)	Applied Forces from other Logs: $F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type D Stability Analysis



Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

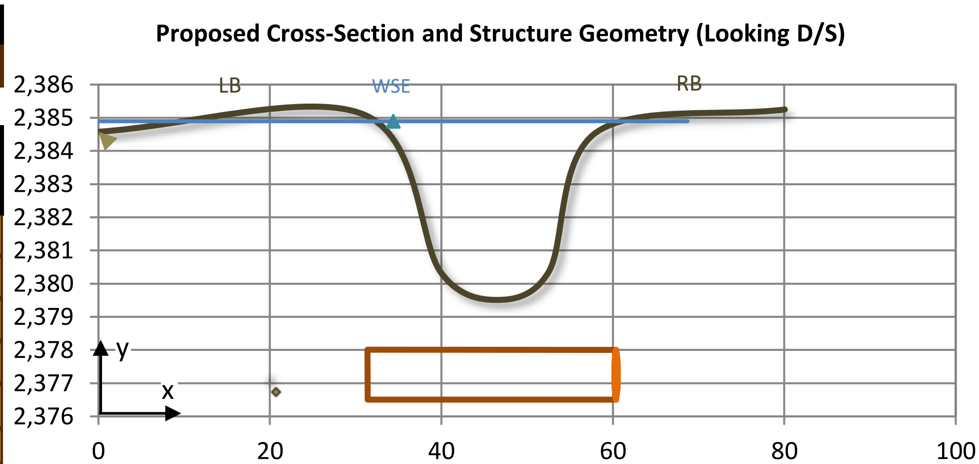
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type D	Log Weir	Full span	Straight	10+90	5.38	31.25	2.62

Multi-Log Structures	Layer	Log ID
	Stacked	Bot

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	31.0	2,385.1
Toe LB	39.9	2,380.4
Thalweg	46.4	2,379.5
Toe RB	52.5	2,380.3
Top RB	58.1	2,384.6
Fldpln RB	80.1	2,385.2

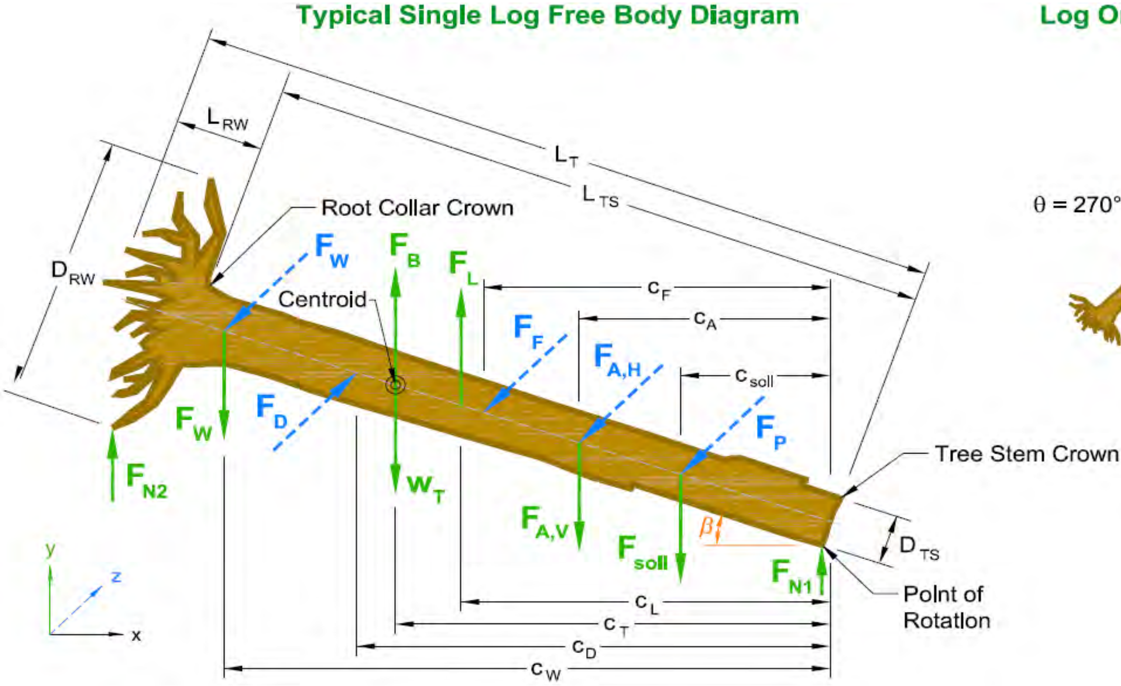


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.50	-	-	33.5	38.0

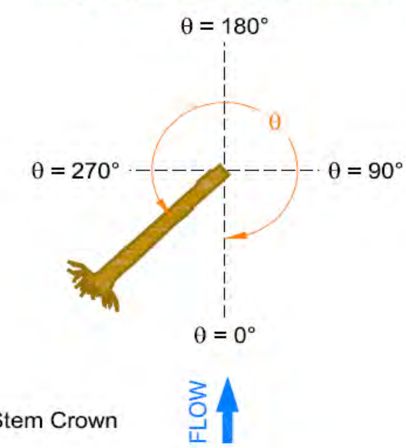
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	105.0	0.0	Stem tip: Bottom	31.40	2,376.51	2,376.50	2,378.01	0.00

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	13.05	2.34	1.92
Bank	Gravel/cobble	137.0	85.3	41.0	4	16.95	6.85	4.84

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	0.0	0.0	0.0	0	0
↓Thalweg	53.0	0.0	53.0	2,015	3,308
Total	53.0	0.0	53.0	2,015	3,308

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	3,308	↑
F_L (lbf)	0	
W_T (lbf)	2,015	↓
F_{soil} (lbf)	13,622	↓
$F_{W,V}$ (lbf)	4,135	↓
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	16,463	↓
FS_V	5.98	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	37.7	37.7	3,153
Bank	0.0	122.7	122.7	10,469
Total	0.0	160.4	160.4	13,622

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.00	0.38	1.13	0.00	1.13	0

Horizontal Force Balance

F_D (lbf)	0	
F_P (lbf)	32,794	←
F_F (lbf)	14,311	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	47,106	←
FS_H	94,230.16	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	7,591	15.05	0.87	6,731
Bank	4.81	25,203	16.95	0.87	7,581
Total	-	32,794	32.00	-	14,311

Moment Force Balance

Driving Moment Centroids			Resisting Moment Centroids			
$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	0.0	0.0	15.0	15.0	15.0	15.0

*Distances are from the stem tip

Point of Rotation: Root Collar

Moment Force Balance

M_d (lbf)	49,636
M_r (lbf)	1,312,140
FS_M	26.44 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Applied Forces from other Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
Top	Above	Gravity	0.0	-4,135	24,794	4,135	↓	0
						0		0
						0		0
						0		0

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

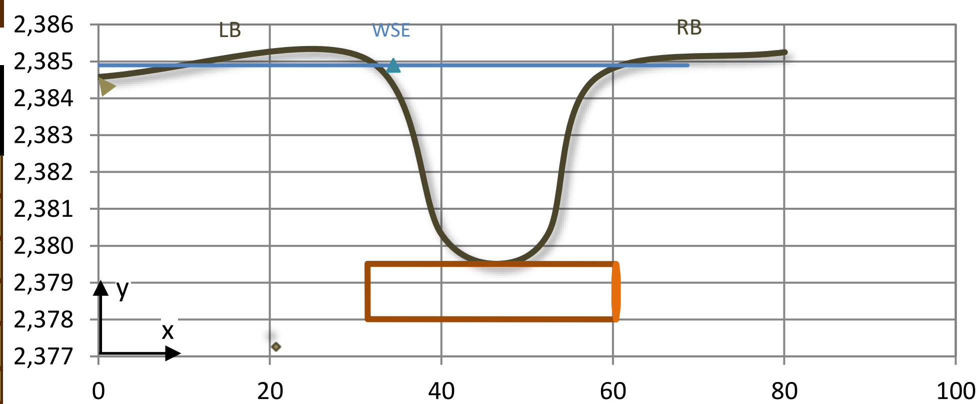
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type D	Log Weir	Full span	Straight	10+90	5.38	31.25	2.62

Multi-Log Structures	Layer	Log ID
	Stacked	Top

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.0	2,384.6
Top LB	31.0	2,385.1
Toe LB	39.9	2,380.4
Thalweg	46.4	2,379.5
Toe RB	52.5	2,380.3
Top RB	58.1	2,384.6
Fldpln RB	80.1	2,385.2

Proposed Cross-Section and Structure Geometry (Looking D/S)



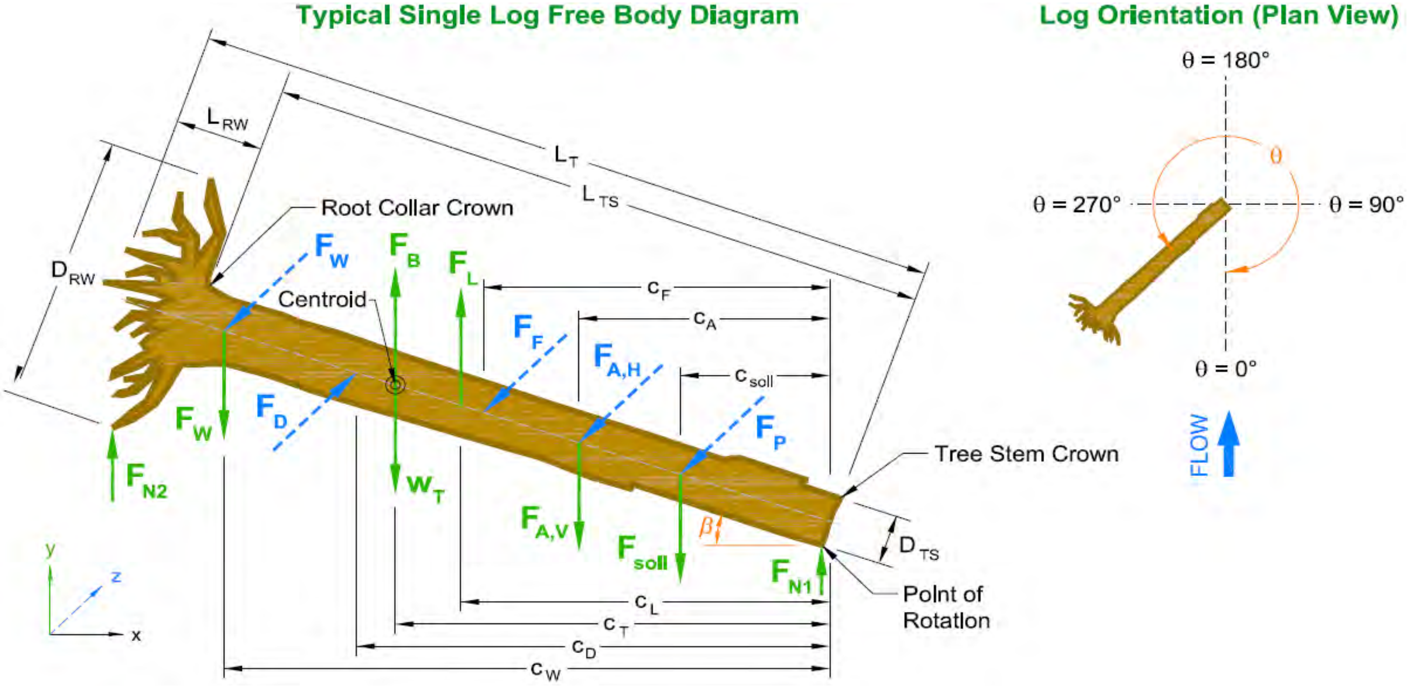
Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.50	-	-	33.5	38.0

Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	105.0	0.0	Stem tip: Bottom	31.40	2,378.01	2,378.00	2,379.51	0.00

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	φ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	13.05	0.84	0.42
Bank	Gravel/cobble	137.0	85.3	41.0	4	16.95	5.35	3.34

Typical Single Log Free Body Diagram

Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	0.0	0.0	0.0	0	0
↓Thalweg	53.0	0.0	53.0	2,015	3,308
Total	53.0	0.0	53.0	2,015	3,308

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	3,308
F_L (lbf)	0
W_T (lbf)	2,015
F_{soil} (lbf)	7,910
$F_{W,V}$ (lbf)	0
$F_{A,V}$ (lbf)	0
ΣF_V (lbf)	6,616
FS_V	3.00

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	8.3	8.3	694
Bank	0.0	84.6	84.6	7,215
Total	0.0	92.9	92.9	7,910

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.00	0.38	1.13	0.00	1.13	0

Horizontal Force Balance

F_D (lbf)	0
F_P (lbf)	19,043
F_F (lbf)	5,751
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
ΣF_H (lbf)	24,794
FS_H	49,598.51

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	1,672	15.05	0.87	2,705
Bank	4.81	17,371	16.95	0.87	3,046
Total	-	19,043	32.00	-	5,751

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	0.0	0.0	15.0	15.0	15.0	15.0

*Distances are from the stem tip

Point of Rotation: Root Collar

Moment Force Balance

M_d (lbf)	49,636
M_r (lbf)	620,025
FS_M	12.49

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Applied Forces from other Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type E Stability Analysis

Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

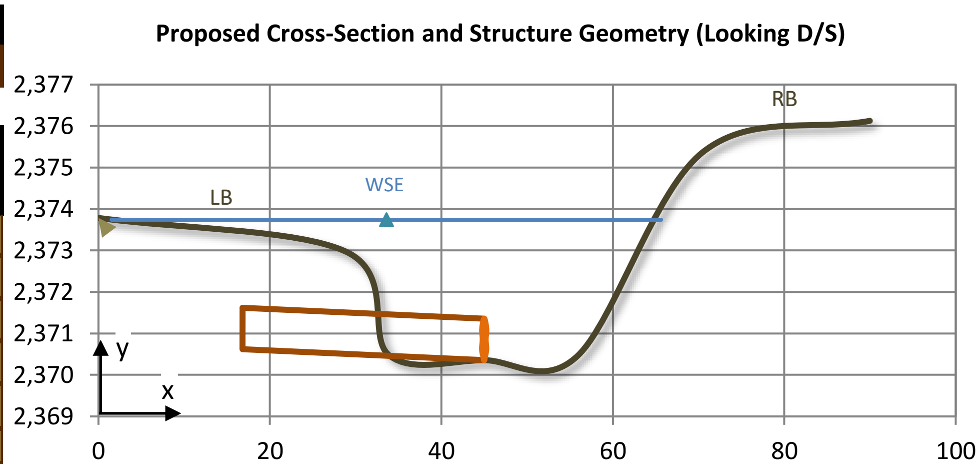
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type E	Log Vane	Left bank	Straight	7+70	3.39	31.26	4.13

Multi-Log Structures	Layer	Log ID
	N/A	N/A

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.00	2,373.78
Top LB	28.93	2,372.97
Toe LB	33.93	2,370.47
Thalweg	44.97	2,370.36
Toe RB	55.92	2,370.47
Top RB	70.43	2,375.36
Fldpln RB	89.98	2,376.13

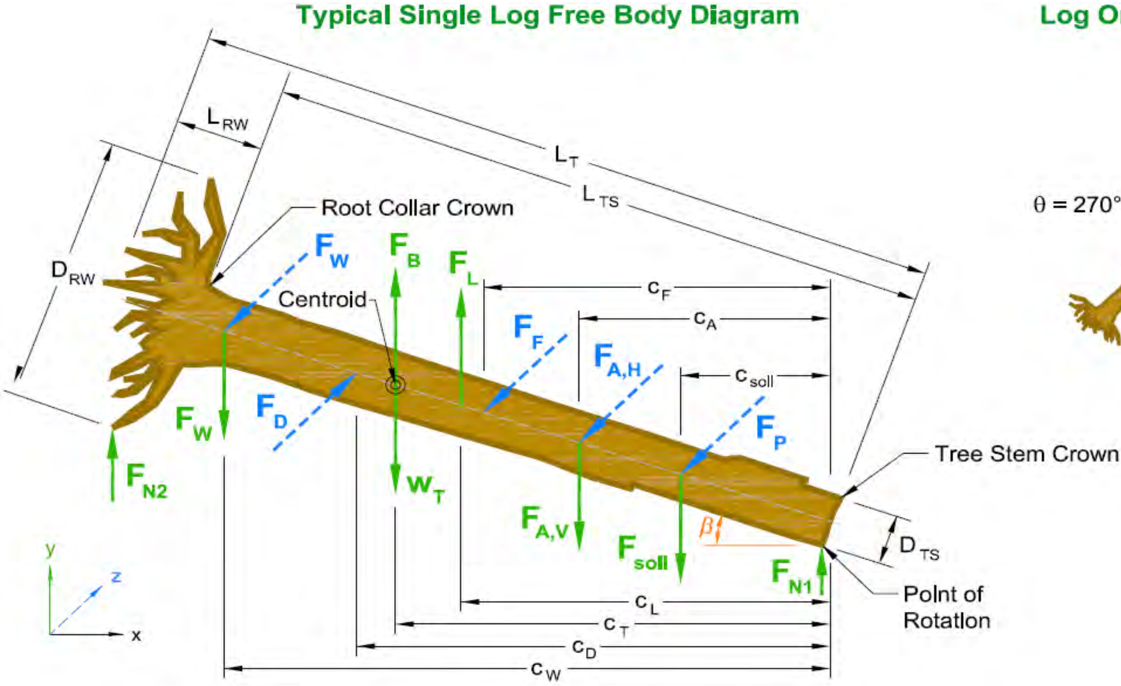


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	No	30.0	1.00	-	-	33.5	38.0

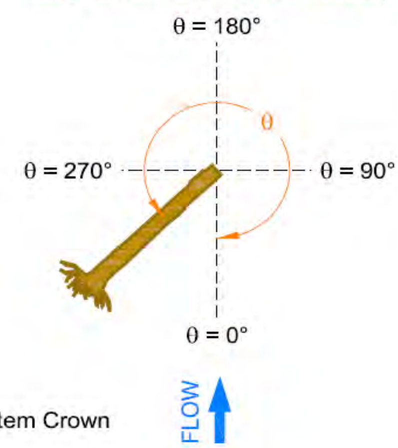
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	110.0	0.5	Root collar: Crown	45.00	2,371.36	2,370.36	2,371.62	11.94

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	16.07	1.69	1.41

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	23.6	0.0	23.6	790	1,470
↓Thalweg	0.0	0.0	0.0	0	0
Total	23.6	0.0	23.6	790	1,470

Lift Force

C_{LT}	0.01
F_L (lbf)	2

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	22.6	22.6	1,931
Total	0.0	22.6	22.6	1,931

Vertical Force Balance

F_B (lbf)	1,470
F_L (lbf)	2
W_T (lbf)	790
F_{soil} (lbf)	1,931
$F_{W,V}$ (lbf)	0
$F_{A,V}$ (lbf)	0
ΣF_V (lbf)	1,250
FS_V	1.85

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.17	0.73	1.12	0.14	1.87	370

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	13.48	0.87	462
Bank	4.81	4,650	18.23	0.87	625
Total	-	4,650	31.70	-	1,086

Horizontal Force Balance

F_D (lbf)	370
F_P (lbf)	4,650
F_F (lbf)	1,086
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
ΣF_H (lbf)	5,367
FS_H	15.52

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
15.0	29.8	23.1	15.0	8.0	14.9	10.7

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	30,649
M_r (lbf)	111,798
FS_M	3.65

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs	
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type F Stability Analysis

Date of Last Revision: August 19, 2021

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

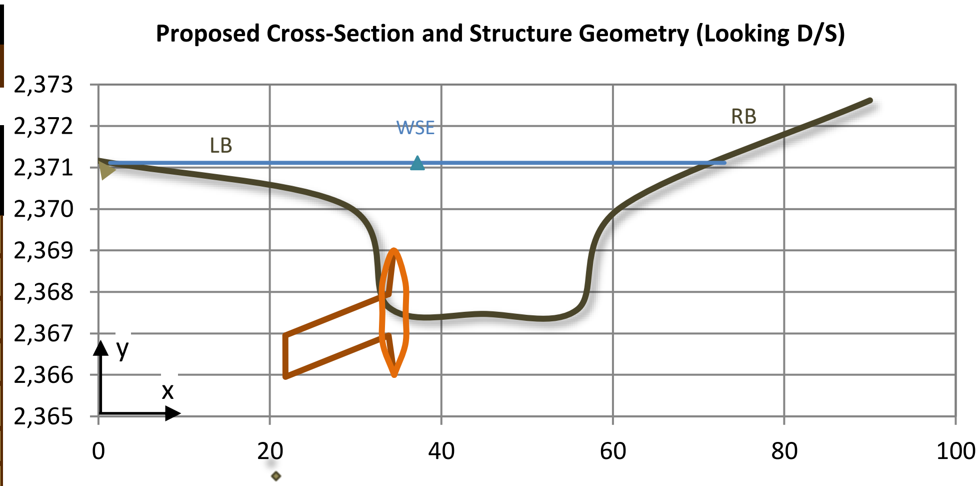
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type F	Rootwad	Left bank	Straight	6+75	3.64	6.25	3.42

Multi-Log Structures	Layer	Log ID
	N/A	N/A

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	0.00	2,371.16
Top LB	28.89	2,370.08
Toe LB	33.89	2,367.62
Thalweg	44.95	2,367.47
Toe RB	55.88	2,367.58
Top RB	60.88	2,370.03
Fldpln RB	90.00	2,372.62

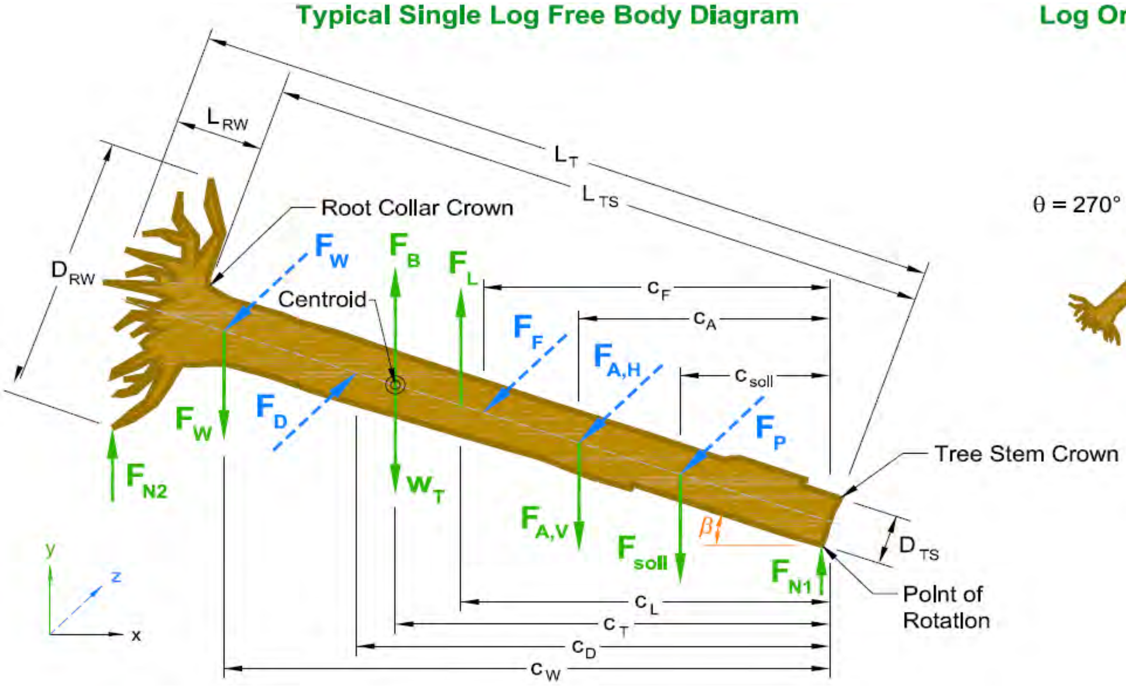


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

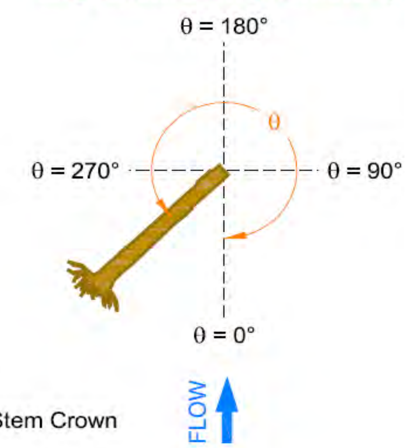
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	155.0	-2.0	Rootwad: Bottom	34.50	2,366.00	2,365.95	2,369.00	3.54

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	27.28	3.40	2.33

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	0.0	0.0	0.0	0	0
↓WS↑Thw	2.1	2.1	4.2	141	262
↓Thalweg	20.3	2.0	22.3	846	1,390
Total	22.4	4.1	26.5	987	1,652

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	1,652	↑
F_L (lbf)	0	
W_T (lbf)	987	↓
F_{soil} (lbf)	5,394	↓
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
Σ F_V (lbf)	4,730	↓
FS_V	3.86	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	63.2	63.2	5,394
Total	0.0	63.2	63.2	5,394

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.05	0.60	0.76	0.04	0.89	36

Horizontal Force Balance

F_D (lbf)	36	→
F_P (lbf)	12,987	←
F_F (lbf)	4,112	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
Σ F_H (lbf)	17,062	←
FS_H	478.36	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	3.43	0.87	440
Bank	4.81	12,987	28.57	0.87	3,671
Total	-	12,987	32.00	-	4,112

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.5	0.0	28.7	16.5	13.6	15.0	18.1

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	28,263
M_r (lbf)	456,913
FS_M	16.17 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs	
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14

LWM Type G Stability Analysis

Date of Last Revision: **August 19, 2021**

Designer:
A. Morton, PE

Reviewed by:
R. Carnie, PE

Large Wood Structure Stability Analysis Spreadsheet was developed by Michael Rafferty, P.E.
Version 1.1

Reference for Companion Paper:

Rafferty, M. 2016. *Computational Design Tool for Evaluating the Stability of Large Wood Structures.* Technical Note TN-103.1. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, National Stream & Aquatic Ecology Center. 27 p.

Lapwai Creek Reach 14

Spreadsheet developed by
Michael Rafferty, P.E.

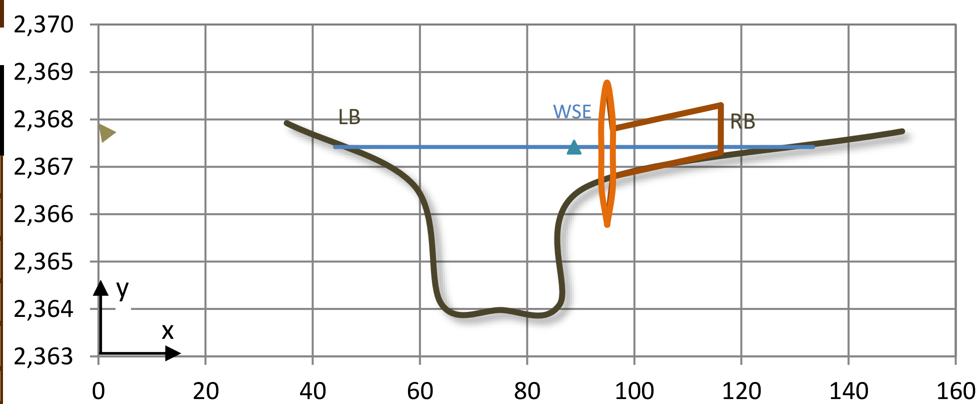
Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type G	Floodplain	Right bank	Straight	5+60	3.44	31.25	2.81

Multi-Log Structures	Layer	Log ID
	Stacked	Surface

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	35.13	2,367.92
Top LB	59.03	2,366.59
Toe LB	64.03	2,364.10
Thalweg	75.04	2,363.98
Toe RB	86.02	2,364.09
Top RB	91.02	2,366.57
Fldpln RB	150.00	2,367.75

Proposed Cross-Section and Structure Geometry (Looking D/S)

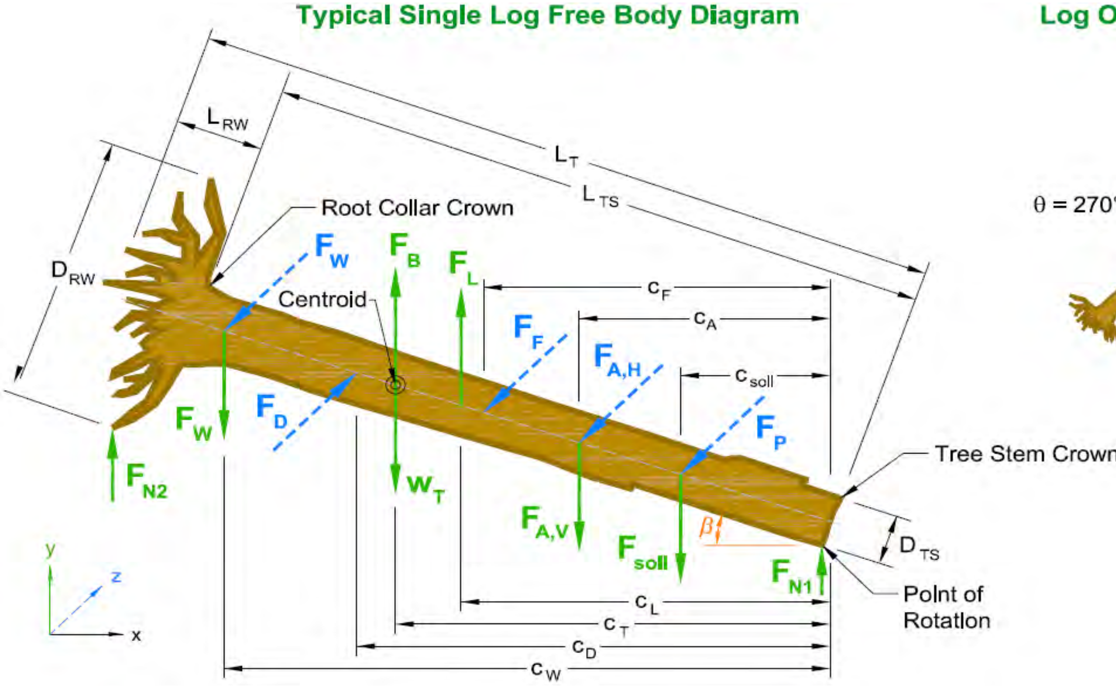


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

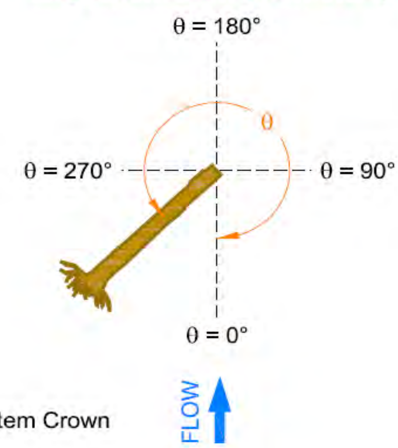
Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	315.0	1.0	Root collar: Bottom	96.00	2,366.80	2,365.77	2,368.77	10.89

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	0.00	0.00	0.00

Typical Single Log Free Body Diagram



Log Orientation (Plan View)



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	14.9	1.7	16.6	558	0
↓WS↑Thw	7.5	2.4	9.8	330	614
↓Thalweg	0.0	0.0	0.0	0	0
Total	22.4	4.1	26.5	888	614

Lift Force

C_{LT}	0.29
F_L (lbf)	24

Vertical Force Balance

F_B (lbf)	614
F_L (lbf)	24
W_T (lbf)	888
F_{soil} (lbf)	0
$F_{W,V}$ (lbf)	1,781
$F_{A,V}$ (lbf)	0
ΣF_V (lbf)	2,031
FS_V	4.18

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	0.0	0.0	0
Total	0.0	0.0	0.0	0

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.16	0.50	0.76	0.00	1.09	91

Horizontal Force Balance

F_D (lbf)	91
F_P (lbf)	0
F_F (lbf)	1,766
$F_{W,H}$ (lbf)	0
$F_{A,H}$ (lbf)	0
ΣF_H (lbf)	1,675
FS_H	19.50

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	1,766
Bank	4.81	0	0.00	0.87	0
Total	-	0	2.00	-	1,766

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.6	15.0	15.0	16.6	0.0	30.0	0.0

*Distances are from the stem tip

Point of Rotation: Rootwad

Moment Force Balance

M_d (lbf)	9,945
M_r (lbf)	38,611
FS_M	3.88

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

						Applied Forces from other Logs		
Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	$F_{W,V}$ (lbf)		$F_{W,H}$ (lbf)
Buried	Above	Gravity	15.0	-1,781	10,214	1,781	↓	0
						0		0
						0		0
						0		0

Lapwai Creek Reach 14

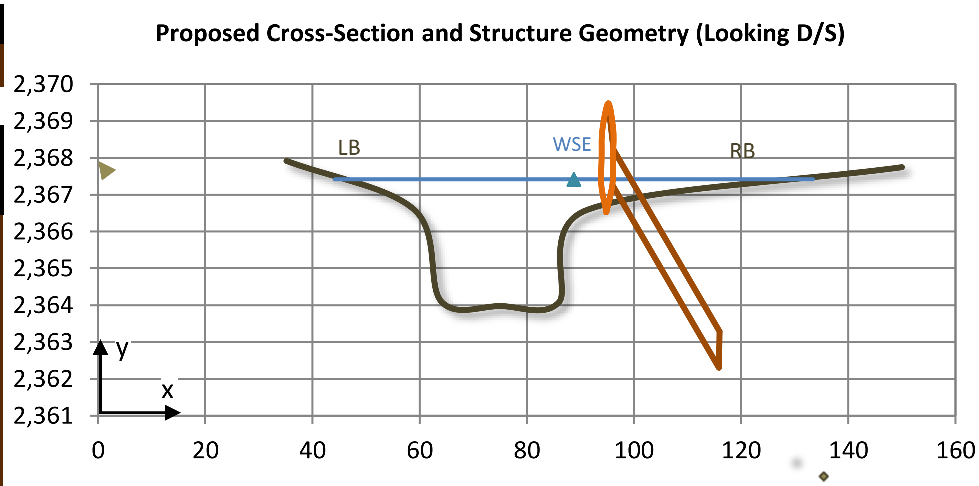
Spreadsheet developed by
Michael Rafferty, P.E.

Single Log Stability Analysis Model Inputs

Site ID	Structure Type	Structure Position	Meander	Station	d_w (ft)	R_c/W_{BF}	u_{des} (ft/s)
Type G	Floodplain	Right bank	Straight	5+60	3.44	31.25	2.81

Multi-Log Structures	Layer	Log ID
	Stacked	Buried

Channel Geometry Coordinates		
Proposed	x (ft)	y (ft)
Fldpln LB	35.13	2,367.92
Top LB	59.03	2,366.59
Toe LB	64.03	2,364.10
Thalweg	75.04	2,363.98
Toe RB	86.02	2,364.09
Top RB	91.02	2,366.57
Fldpln RB	150.00	2,367.75

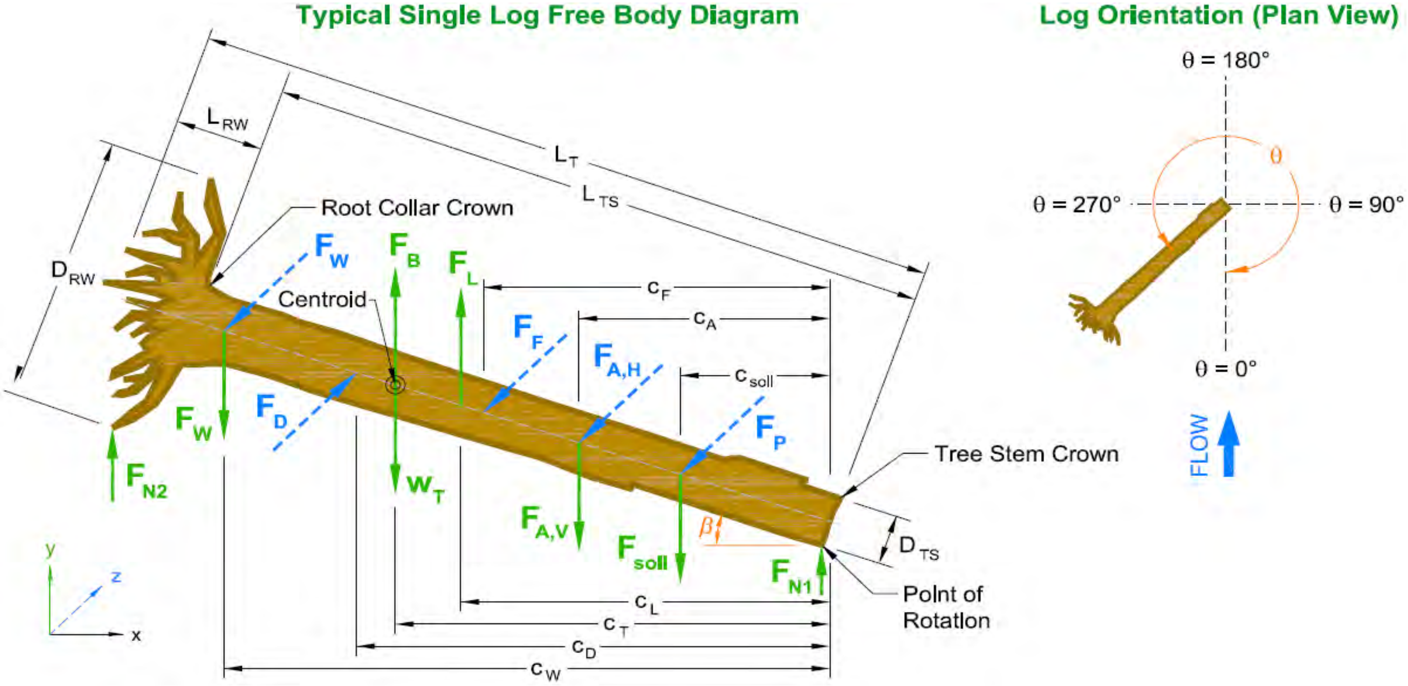


Wood Species	Rootwad	L_T (ft)	D_{TS} (ft)	L_{RW} (ft)	D_{RW} (ft)	γ_{Td} (lb/ft^3)	γ_{Tgr} (lb/ft^3)
Douglas-fir, Interior north	Yes	30.0	1.00	1.50	3.00	33.5	38.0

Structure Geometry	θ (deg)	β (deg)	Define Fixed Point	x_T (ft)	y_T (ft)	$y_{T,min}$ (ft)	$y_{T,max}$ (ft)	A_{Tp} (ft^2)
	315.0	-10.0	Root collar: Bottom	96.00	2,367.25	2,362.30	2,369.48	4.22

Soils	Material	γ_s (lb/ft^3)	γ'_s (lb/ft^3)	ϕ (deg)	Soil Class	$L_{T,em}$ (ft)	$d_{b,max}$ (ft)	$d_{b,avg}$ (ft)
Stream Bed	Small Cobble	134.5	83.7	41.0	4	0.00	0.00	0.00
Bank	Gravel/cobble	137.0	85.3	41.0	4	20.18	3.78	1.90

Typical Single Log Free Body Diagram **Log Orientation (Plan View)**



Vertical Force Analysis

Net Buoyancy Force

Wood	V_{TS} (ft^3)	V_{RW} (ft^3)	V_T (ft^3)	W_T (lbf)	F_B (lbf)
↑WSE	1.5	3.1	4.6	154	0
↓WS↑Thw	15.5	1.0	16.5	554	1,030
↓Thalweg	5.4	0.0	5.4	203	334
Total	22.4	4.1	26.5	912	1,364

Lift Force

C_{LT}	0.00
F_L (lbf)	0

Vertical Force Balance

F_B (lbf)	1,364	↑
F_L (lbf)	0	
W_T (lbf)	912	↓
F_{soil} (lbf)	3,257	↓
$F_{W,V}$ (lbf)	0	
$F_{A,V}$ (lbf)	0	
ΣF_V (lbf)	2,805	↓
FS_V	3.06	✓

Soil Ballast Force

Soil	V_{dry} (ft^3)	V_{sat} (ft^3)	V_{soil} (ft^3)	F_{soil} (lbf)
Bed	0.0	0.0	0.0	0
Bank	0.0	38.2	38.2	3,257
Total	0.0	38.2	38.2	3,257

Horizontal Force Analysis

Drag Force

A_{Tp} / A_W	Fr_L	C_{Di}	C_w	C_D*	F_D (lbf)
0.06	0.50	0.76	0.43	1.36	44

Horizontal Force Balance

F_D (lbf)	44	→
F_P (lbf)	7,842	←
F_F (lbf)	2,438	←
$F_{W,H}$ (lbf)	0	
$F_{A,H}$ (lbf)	0	
ΣF_H (lbf)	10,236	←
FS_H	234.45	✓

Passive Soil Pressure / Friction Force

Soil	K_P	F_P (lbf)	L_{Tf} (ft)	μ	F_F (lbf)
Bed	4.81	0	2.00	0.87	178
Bank	4.81	7,842	25.42	0.87	2,260
Total	-	7,842	27.42	-	2,438

Moment Force Balance

Driving Moment Centroids / Resisting Moment Centroids

$c_{T,B}$ (ft)	c_L (ft)	c_D (ft)	$c_{T,W}$ (ft)	c_{soil} (ft)	$c_{F\&N}$ (ft)	c_P (ft)
16.5	0.0	24.8	16.5	10.1	12.7	13.4

*Distances are from the stem tip

Point of Rotation: Stem Tip

Moment Force Balance

M_d (lbf)	23,295
M_r (lbf)	216,013
FS_M	9.27 ✓

Anchor Forces

Additional Soil Ballast

V_{Adry} (ft^3)	V_{Awet} (ft^3)	c_{Asoil} (ft)	$F_{A,Vsoil}$ (lbf)	$F_{A,HP}$ (lbf)
			0	0

Mechanical Anchors

Type	c_{Am} (ft)	Soils	F_{Am} (lbf)
			0
			0

Boulder Ballast

Position	D_r (ft)	c_{Ar} (ft)	$V_{r,dry}$ (ft^3)	$V_{r,wet}$ (ft^3)	W_r (lbf)	$F_{L,r}$ (lbf)	$F_{D,r}$ (lbf)	$F_{A,Vr}$ (lbf)	$F_{A,Hr}$ (lbf)
								0	0
								0	0
								0	0

Interaction Forces with Adjacent Logs

Log ID	Position	Link	c_{WI} (ft)	$F_{W,V}$ (lbf)	$F_{W,H}$ (lbf)	Applied Forces from other Logs: $F_{W,V}$ (lbf)	Applied Forces from other Logs: $F_{W,H}$ (lbf)
						0	0
						0	0
						0	0
						0	0

Lapwai Creek Reach 14
Notation, Units, and List of Symbols

Notation

Symbol	Description	Unit
A_W	Wetted area of channel at design discharge	ft^2
A_{Tp}	Projected area of wood in plane perpendicular to flow	ft^2
c_D	Centroid of the drag force along log axis	ft
c_{Am}	Centroid of a mechanical anchor along log axis	ft
c_{Ar}	Centroid of a ballast boulder along log axis	ft
c_{Asoil}	Centroid of the added ballast soil along log axis	ft
$c_{F\&N}$	Centroid of friction and normal forces along log axis	ft
c_L	Centroid of the lift force along log axis	ft
c_P	Centroid of the passive soil force along log axis	ft
c_{soil}	Centroid of the vertical soil forces along log axis	ft
$c_{T,B}$	Centroid of the buoyancy force along log axis	ft
$c_{T,W}$	Centroid of the log volume along log axis	ft
c_{WI}	Centroid of a wood interaction force along log axis	ft
C_{Lrock}	Coefficient of lift for submerged boulder	-
C_{LT}	Effective coefficient of lift for submerged tree	-
C_{Di}	Base coefficient of drag for tree, before adjustments	-
C_D*	Effective coefficient of drag for submerged tree	-
C_{Di}	Base coefficient of drag for tree, before adjustments	-
C_W	Wave drag coefficient of submerged tree	-
$d_{b,avg}$	Average buried depth of log	ft
$d_{b,max}$	Maximum buried depth of log	ft
d_w	Maximum flow depth at design discharge in reach	ft
D_{50}	Median grain size in millimeters (SI units)	mm
D_r	Equivalent diameter of boulder	ft
D_{RW}	Assumed diameter of rootwad	ft
D_{TS}	Nominal diameter of tree stem (DBH)	ft
DF_{RW}	Diameter factor for rootwad ($DF_{RW} = D_{RW}/D_{TS}$)	-
e	Void ratio of soils	-
$F_{A,H}$	Total horizontal load capacity of anchor techniques	lbf
$F_{A,HP}$	Passive soil pressure applied to log from soil ballast	lbf
$F_{A,Hr}$	Horizontal resisting force on log from boulder	lbf
F_{Am}	Load capacity of mechanical anchor	lbf
$F_{A,V}$	Total vertical load capacity of anchor techniques	lbf
$F_{A,Vr}$	Vertical resisting force on log from boulder	lbf
$F_{A,Vsoil}$	Vertical soil loading on log from added ballast soil	lbf
F_B	Buoyant force applied to log	lbf
F_D	Drag forces applied to log	lbf
$F_{D,r}$	Drag forces applied to boulder	lbf
F_F	Friction force applied to log	lbf
F_H	Resultant horizontal force applied to log	lbf
F_L	Lift force applied to log	lbf
$F_{L,r}$	Lift force applied to boulder	lbf
F_P	Passive soil pressure force applied to log	lbf
F_{soil}	Vertical soil loading on log	lbf
$F_{W,H}$	Horizontal forces from interactions with other logs	lbf
$F_{W,V}$	Vertical forces from interactions with other logs	lbf

Notation (continued)

Symbol	Description	Unit
F_V	Resultant vertical force applied to log	lbf
Fr_L	Log Froude number	-
FS_V	Factor of Safety for Vertical Force Balance	-
FS_H	Factor of Safety for Horizontal Force Balance	-
FS_M	Factor of Safety for Moment Force Balance	-
g	Gravitational acceleration constant	ft/s^2
K_P	Coefficient of Passive Earth Pressure	-
$L_{T,em}$	Total embedded length of log	ft
L_{RW}	Assumed length of rootwad	ft
L_T	Total length of tree (including rootwad)	ft
L_{Tf}	Length of log in contact with bed or banks	ft
L_{TS}	Length of tree stem (not including rootwad)	ft
$L_{TS,ex}$	Exposed length of tree stem	ft
LF_{RW}	Length factor for rootwad ($LF_{RW} = L_{RW}/D_{TS}$)	-
M_d	Driving moment about embedded tip	lbf
M_r	Driving moment about embedded tip	lbf
N	Blow count of standard penetration test	-
p_o	Porosity of soil volume	-
Q_{des}	Design discharge	cfs
R	Radius	ft
R_c	Radius of curvature at channel centerline	ft
SG_r	Specific gravity of quartz particles	-
SG_T	Specific gravity of tree	-
u_{avg}	Average velocity of cross section in reach	ft/s
u_{des}	Design velocity	ft/s
u_m	Adjusted velocity at outer meander bend	ft/s
V_{dry}	Volume of soils above stage level of design flow	ft^3
V_{sat}	Volume of soils below stage level of design flow	ft^3
V_{soil}	Total volume of soils over log	ft^3
V_{RW}	Volume of rootwad	ft^3
V_S	Volume of solids in soil (void ratio calculation)	ft^3
V_T	Total volume of log	ft^3
V_{TS}	Total volume of tree	ft^3
V_V	Volume of voids in soil	ft^3
V_{Adry}	Volume of ballast above stage of design flow	ft^3
V_{Awet}	Volume of ballast below stage of design flow	ft^3
$V_{r,dry}$	Volume of boulder above stage of design flow	ft^3
$V_{r,wet}$	Volume of boulder below stage of design flow	ft^3
W_{BF}	Bankfull width at structure site	ft
W_r	Effective weight of boulder	lbf
W_T	Total log weight	lbf
x	Horizontal coordinate (distance)	ft
y	Vertical coordinate (elevation)	ft
$y_{T,max}$	Minimum elevation of log	ft
$y_{T,min}$	Maximum elevation of log	ft

Greek Symbols

Symbol	Description	Unit
β	Tilt angle from stem tip to vertical	deg
γ_{bank}	Dry specific weight of bank soils	lb/ft^3
$\gamma_{bank,sat}$	Saturated unit weight of bank soils	lb/ft^3
γ'_{bank}	Effective buoyant unit weight of bank soils	lb/ft^3
γ_{bed}	Dry specific weight of stream bed substrate	lb/ft^3
γ'_{bed}	Effective buoyant unit weight of stream bed substrate	lb/ft^3
γ_{rock}	Dry unit weight of boulders	lb/ft^3
γ_s	Dry specific weight of soil	lb/ft^3
γ'_s	Effective buoyant unit weight of soil	lb/ft^3
γ_{Td}	Air-dried unit weight of tree (12% MC basis)	lb/ft^3
γ_{Tgr}	Green unit weight of tree	lb/ft^3
γ_w	Specific weight of water at 50ºF	lb/ft^3
η	Rootwad porosity	-
θ	Rootwad (or large end of log) orientation to flow	deg
μ	Coefficient of friction	-
ν	Kinematic viscosity of water at 50ºF	ft/s^2
Σ	Sum of forces	-
ϕ_{bank}	Internal friction angle of bank soils	deg
ϕ_{bed}	Internal friction angle of stream bed substrate	deg

Units

Notation	Description
cfs	Cubic feet per second
ft	Feet
lb	Pound
lbf	Pounds force
kg	Kilograms
m	Meters
mm	Millimeters
s	Seconds
yr	Year

Abbreviations

Notation	Description
ARI	Average return interval
Avg	Average
DBH	Diameter at breast height
deg	Degrees
Dia	Diameter
Dist	Distance
D/S	Downstream
ELJ	Engineered log jam
Ex	Example
Fldpln	Floodplain
H&H	Hydrologic and hydraulic
ID	Identification
i.e.	That is
LB	Left bank
LW	Large wood
Max	Maximum
MC	Moisture content
Min	Minimum
ML	Multi-log
SL	Single log
N/A	Not applicable
no	Number
Pt	Point
rad	Radians
RB	Right bank
RW	Rootwad
SL	Single log
Thw	Thalweg (lowest elevation in channel bed)
Typ	Typical
U.S.	United States
WS	Water surface
WSE	Water surface elevation
↑	Above
↓	Below

APPENDIX F
Construction Quantities and Estimate of Anticipated Costs

Channel Construction Cost Workbook

Project:	Lapwai Creek Reach 14	**Analyst:**	AM / RC
Project Number:	00571-022-00	**Latest Revision:**	04/14/22

Workbook Description

- This workbook contains spreadsheets that facilitate the analysis and/or design of this project.
- This spreadsheet lists the general project and workbook information that is consistent throughout the workbook.
- It also lists the titles of the spreadsheets contained in this workbook.
- This workbook is limited to the Construction Cost Estimate for modifications identified in the GeoEngineers Construction drawings and does **NOT** include the modifications proposed by others.
- This workbook is intended for use with ENGLISH UNITS.

Sheet Titles:

Channel Construction Cost Workbook
Unit Costs
Project Total Bid Sheet
Total Summary

Project Total Bid Sheet

Project: Lapwai Creek Reach 14
Project Number: 00571-022-00

Analyst: AM / RC
Latest Revision: 4/14/2022

- This spreadsheet summarizes the construction quantities for all preliminary construction bid items.

Item #	Item Description	Units	Unit Cost	No. of Units	Total Cost ($)
1	Mobilization and Demobilization	LS		1	
2	Erosion and Sediment Control	LS		1	
3	Environmental Protections	LS		1	
4	Temporary Work Area Isolation	LS		1	
5	Temporary Stream Diversion	CY		1000	
6	Clearing and Grubbing	AC		2	
7	Excavation	CY		3727	
8	Placement of Stockpiled Material	CY		3727	
9	Riffle Cobbles (10 In - 12 in)	CY		35	
10	In-stream structure LWM Type A	EA		4	
11	In-stream structure LWM Type B	EA		5	
12	In-stream structure LWM Type C	EA		4	
13	In-stream structure LWM Type D	EA		2	
14	In-stream structure LWM Type E	EA		4	
15	In-stream structure LWM Type F	EA		6	
16	In-stream structure LWM Type G	EA		11	
17	Rock Weirs	EA		8	
18	Boulder Clusters	EA		50	
19	Permanent Seeding, Fertilizing Mulching and Weed Control	AC		2	
20	Planting	EA		4250	
	Construction Total				

APPENDIX G
HIP Project Review Comment Tracking

HIP Project Review
Comment Tracking

Project Information:

Project Name:	Lapwai Reach 14A
BPA Project #:	1999-017-00
Contract #:	74017 REL 71
Sponsor:	Nez Perce Tribe, Travis House
Designer:	GeoEngineers
Area Lead:	Eric Leitzinger, EWM, Upper Snake Lead
COR/PM:	Jennifer Lord, EWM
HIP Program Lead:	Daniel A. Gambetta, ECF

HIP Review Team:

BPA EC Lead:	Carolyn Sharp
BPA Technical Lead:	Christopher J. Nygaard, P.E., EWL
NMFS Branch Chief:	Kenneth Troyer, NMFS, Northern Snake Branch Chief
NMFS Biologist:	name
NMFS Engineer:	Dropdown Menu
USFWS Field Office:	N/A
USFWS Reviewer:	name

Documents Reviewed:

Lapwai Reach 14 15% Conceptual Design Memo – June 25, 2021
Lapwai Reach 14 80% BOD – dated Aug 25, 2021

Activity Categories:	**Risk Level:**
2a - Improve Secondary Channel and Floodplain Connectivity	Medium
2d - Install Habitat-Forming Instream Structures	Medium
2e - Riparian and Wetland Vegetation Planting	Low
2f - Channel Reconstruction	Medium
Overall Project Risk	**Medium**

Review Timeline:	**Date Completed**
• Conceptual Review (typically 15%)	
o Site visit, if needed	Not Started
o Sponsor to submit conceptual design to EC Lead and COR	6/30/2021
o EC Lead to submit concept to HIP Review Team to initiate review	6/30/2021
o EC Lead to send design package to appropriate HIP Review members	6/30/2021
o EC Lead to compile comments and forward to Sponsor	7/8/2021
o Sponsor to provide responses to EC Lead	9/2/2021
o HIP Review Team and Sponsor to resolve “open” comments	Not Started
o EC Lead to notify Sponsor to proceed to preliminary design	7/8/2021
• Permit Level Design Review (typically 60% to 80%)	
o Sponsor to submit design package to EC lead and COR	8/31/2021
o EC Lead to submit design package to HIP Review Team	8/31/2021
o EC Lead to compile comments and forward to Sponsor	Not Started
o Sponsor to provide responses to EC Lead	Not Started
o HIP Review Team and Sponsor to resolve “open” comments	Not Started
o EC Lead to notify Sponsor to proceed to final design	Not Started
• Final Design Package (100%)	
o Sponsor to submit final designs to EC Lead and COR	Not Started
o EC Lead and BPA Technical Lead to verify no critical changes	Not Started

HIP Project Review
Comment Tracking

Comments:

#	Reviewer (Org.)	Date	Document	Page/ Section	Comment		Response by (Org.)	Date	Response to Comment	Status (BPA to Update)
1	BPA	7/1/21	General		Mark drawings according to Idaho Statute 54-1215(b): The seal, signature and date shall be placed on all final specifications, land surveys, reports, plats, drawings, plans, design information and calculations, whenever presented to a client or any public or governmental agency. Any such document presented to a client or public or governmental agency that is not final and does not contain a seal, signature and date shall be clearly marked as "draft," "not for construction" or with similar words to distinguish the document from a final document.		GeoEngineers	08/26/21	The 80 Percent design drawings include a note that indicates they are preliminary and not for construction. Because the report, design drawings and specifications are not final, they have not been stamped by an engineer licensed in the state of Idaho.	For Information Only
2	BPA	7/1/21 9/2/21	General		The conceptual memo and plans clearly articulate project goals and design direction. BPA supports the design approach and proposes to advance and plans, specification and reporting directly to the 80% submittal with one interim technical check-in by video conference. Please plan for a 1-2 hour project development check-in at the approximate 30-60% design phase. For the interim check-in , please prepare to present project planning, H&H analysis, draft plans showing all major project features, channel cross sections and profiles, draft quantities and project costs. **Update:** Comment closed		GeoEngineers	8/30/21	A draft version of the 80 percent design drawings were submitted to BPA on August 25, 2021. GeoEngineers attended a coordination call regarding the draft 80 percent design drawing submittal on August 26, 2021.	Closed

HIP Project Review
Comment Tracking

#	Reviewer (Org.)	Date	Document	Page/ Section	Comment		Response by (Org.)	Date	Response to Comment	Status (BPA to Update)
3	BPA	7/1/21	General		Please review HIP Handbook General and Activity Specific conservation measures (provided with HIP review comments) and ensure that they are incorporated into the design package. In particular, ensure that the plan properly addresses HIP requirements for timing (In water work window), access, staging, water crossings and workplace isolation. **Update:** Given space constraints of narrow stream corridor and adjacent roadway, staging area identified is the only appropriate option.		GeoEngineers	08/31/21	The 80 percent design drawings address the in-water work window, access and staging, water crossings and workplace isolation. The refueling and staging location does not meet the minimum 150-foot separation from the ordinary high water mark. The design mitigates that with the inclusion of a spill prevention BMP and a required spill kit. There is one proposed water crossing and a two-phased stream diversion plan. The basis of design report (BDR) references project elements specific to the relevant activities listed here.	Closed
4	BPA	7/1/21 9/2/21	General		Please include HIP general conservation measure in the plan set. **Update:** Comment closed		GeoEngineers	08/31/21	The HIP general conservation measures are included on the 80 percent design drawings.	Closed
5	BPA	7/1/21 9/2/21	BDR		A Basis of Design report with appropriate technical appendices will be required for the project. Please provide appropriate hydrologic and hydraulic analysis along with a geomorphic stability assessment in the 80% submittal. Please include large wood and rock stability calculations in the 80% submittal. **Update:** Comment closed		GeoEngineers	08/21/21	The 80 percent BDR includes hydrologic, hydraulic, streambed material and proposed boulder stabilization calculations in the appendix. A large wood risk assessment and stability calculations are included in the appendix.	Closed
6	BPA	7/1/21 9/2/21	Plans		The project will require a water management and re-watering plan. Please include in the 80% submittal. **Update:** Comment closed		GeoEngineers	08/31/21	The 80 percent design drawings include a construction sequence design that illustrates a two-phased stream diversion and rewatering plan.	Closed
7	BPA	7/6/21 9/3/21	BDR		Plans refer to presence of bull trout by error of the consultant. Reminder to delete reference. **Update**: Comment Closed		GeoEngineers	08/31/21	The reference to the presence of bull trout that was included in the 15 percent design submittal has been removed and is not included in the 80 percent design submittal.	Closed

#	Reviewer (Org.)	Date	Document	Page/ Section	Comment		Response by (Org.)	Date	Response to Comment	Status (BPA to Update)
8	BPA	9/2/21	Plans	1.1	Please identify if excess cut material will be generated at the site. If there is excess material, add the estimated quantity to construction quantities table on plan sheet 1.1 and identify where the fill is to be placed. HIP requires location outside of 100 year flood plain. Note that if excavation is in excess of 20 cy, HIP Handbook (pg 29) requires a site assessment for potential site contamination.		GeoEngineers	9/14/21	The final design drawings reflect a balanced cut and fill quantity. The placement of excavated material as fill on the project site is proposed outside of the 100-year floodplain. The site does propose more than 20 CY of excavation and a site assessment along with documentation consistent with HIP requirements will be completed by the Project Sponsor.	Open (Requirement)
9	BPA	9/2/21	Plans	4.2	Please add a rood wad size specification to plan sheet 4.2 to supplement the wood schedule.		GeoEngineers	9/14/21	The final design drawings include specifications for rootwad dimensions and acceptance of large wood material to be determined by the contracting officer. We are recommending rootwad size to be 2x DBH.	Open (Recommendation)
10	BPA	9/2//21	Plans	5.3	Please add additional clarity to the boulder diameter specification on sheet 5.3. The current statement would allow all 24" boulders. Recommend stating a minimum % of each intended class. Recommend specifying Footer Boulders separate from Header Boulders to align with plan call-outs.		GeoEngineers	9/14/21	The final design drawings include specific footer and header boulder size requirements. The design drawings also identify the percentage by weight for specified size classes for the boulders.	Open (Recommendation)
11	BPA	9/2/21	Plans	4.1	Recommend removing the 50% slope from typical channel detail on sheet 4.1 and state "varies". The math doesn't line up if intent is 32 ft top of bank consistent with horizontal length summation and detail on sheet 5.3.		GeoEngineers	9/15/21	The final design drawings have provided approximate cross-sectional side slopes and maximum allowed where appropriate.	Open (Recommendation)

#	Reviewer (Org.)	Date	Document	Page/ Section	Comment		Response by (Org.)	Date	Response to Comment	Status (BPA to Update)
12	BPA	9/3/21	Plans	6.1	Revegetation plan seed mix consists of all non-natives. Discussion at meeting 9/2/21 indicated that more work needed on reveg plan in general, including planting details. Please make sure to select a native seed mix per HIP Category 2e Riparian and Wetland Vegetation Planting.		GeoEngineers	9/15/21	The final design reflects native seeding and planting species specifications.	Open (Requirement)
13	BPA	9/3/21	BOD	Section 6.0	Construction details: please include a narrative of methods, materials, equipment that would likely be needed during construction. Discussed during 9/2/21 meeting.		GeoEngineers	9/15/21	The final basis of design report includes a summary description of proposed in-channel construction activities. The summary is included in Section 6 of the report.	Open (Requirement)
14	BPA	9/3/21	BOD	Drawing 2.0	Non-HIP comment for NPT to address: Drawing 2.0 shows property ownership. Does this show that the underlying land is private, but project is within ITD ROW? We've talked about needing agreements with IDT for use of the pullout for staging. What other agreements are needed/planned?		NPT	9/30/21		Not a HIP review comment
15	BPA	9/3/21	BOD	Drawing 3.0	Non-HIP comment for NPT to address: please provide a .shp file of the Project Disturbance Limits to the EC Lead to compare the APE with the 2018 project to figure out if additional cultural resource survey will need to be scheduled before implementation planned for next year.		NPT	9/30/21		Not a HIP review comment

APPENDIX H
Report Limitations and Guidelines for Use

APPENDIX H
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

Some clients, design professionals and contractors may not recognize that stream and river engineering analysis and design practices are less exact than other engineering and natural science disciplines. Such misunderstanding can create unrealistic expectations, sometimes leading to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

Stream and River Design Engineering Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for the Nez Perce Tribe and their authorized agents and regulatory agencies for use on the Project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the Nez Perce Tribe may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project(s), and its (their) schedule and budget, our services have been executed in accordance with our Agreement with the Nez Perce Tribe dated August 11, 2020 and generally accepted practices in this area at the time this report was prepared. We do not authorize and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Stream or River Design Engineering Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Lapwai Creek habitat restoration project in Nez Perce County, Idaho. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site, or
- Completed before project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

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[1] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org.

- The function of the proposed design and/or structure;
- Elevation, configuration, location, orientation or weight of the proposed structures;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations in the context of such changes. Based on that review, we can provide written modifications or confirmation, as appropriate.

Conditions Can Change

This report is based on conditions that existed at the time the study/design was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability, stream flow fluctuations or stream channel fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Report Recommendations and Designs are Not Final

The recommendations included in this report are preliminary and should not be considered final. The designs depicted herein are approximate and are intended to express the overall design intent of the Project and need to be adjusted in the field during construction in order to meet the specific site conditions and intended function. GeoEngineers' recommendations can be finalized only by observing actual site-specific conditions revealed during construction.

We recommend that you allow sufficient monitoring and consultation by GeoEngineers during construction to confirm that the conditions encountered are consistent with those indicated in the report, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated and to evaluate whether construction activities are completed in accordance with our recommendations. GeoEngineers cannot assume responsibility for the recommendations in this report if we do not perform construction observation.

Report Could be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

To help reduce the risk of problems, we recommend giving contractors the complete report, including these "Report Limitations and Guidelines for Use." When providing the report, you preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Hazards of Instream Habitat Structures

Instream habitat structures (“Structures”) create potential hazards, including, but not limited to:

- Persons falling from the Structures and associated injury or death;
- Collisions of recreational users’ and their watercraft with the Structures, and associated risk of injury, and damage of the watercraft;
- Mobilization of a portion or all of the Structures during high water flow conditions and related damage to downstream persons and property;
- Flooding;
- Erosion; and
- Channel avulsion.

In some cases, instream habitat structures are only intended to be temporary, providing temporary stabilization while stream/river processes stabilize. This gradual deterioration with age and vulnerability to major flood events make the risks with temporary Structures inherently greater with their increasing age.

GeoEngineers strongly recommends that the Client appropriately address safety concerns, including but not limited to warning construction workers of hazards associated with working in or near deep and fast-moving water and on steep, slippery and unstable slopes. In addition, signs should be placed along the enhanced stream reaches in prominent locations to warn third parties, such as nearby residents and recreational users, of the potential hazards noted above.

Increased Flood Elevations and Wetland Expansion are Possible

The proposed stream enhancements may result in increased flood elevations and expansion of wetlands. These impacts are generally considered advantageous for aquatic and riparian habitat in the project locations of these stream systems, but the analysis, consideration and quantification of these impacts is beyond the scope of this report, unless expressly included within GeoEngineers’ scope of services.

Channel Erosion and Migration are Possible

In general, river and stream enhancements result in more stable streambeds, banks and floodplains. In some cases, stream enhancement and channel stability include reestablishing the natural balance of sediment erosion, distribution and deposition, which in some cases may induce channel meandering and migration. Therefore, channel erosion, channel migration and/or avulsions can occur over time.

Importance of Monitoring and Maintenance

In some instances, GeoEngineers may have purposely excluded piles, anchors, chains, cables, reinforcing bars, bolts and similar fasteners from structures with the intent of mimicking naturally-occurring instream structures. In other instances, GeoEngineers may have purposely included such fasteners, if considered appropriate. While GeoEngineers designs Structures to be relatively stable during flood events, some movement of these Structures is expected. We recommend that the Client implement appropriate monitoring and maintenance procedures to minimize potential adverse impacts at or near areas of concern, such as at downstream road, bridge and/or culvert crossings, including replacing, adjusting and removing damaged, malfunctioning or deteriorated components of Structures, particularly after a major storm event.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our recommendations are not intended to direct the contractor's procedures, means, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

GeoEngineers