Deadhorse Tunnel Habitat Restoration Project

Conceptual design report

SUBMITTED TO
Yakama Nation Fisheries

December 2018

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Conceptual Design Report

SUBMITTED TO
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1. Introduction

This report presents an initial round of conceptual designs for the Deadhorse Tunnel habitat enhancement project, located on the upper Wenatchee River in Chelan County, Washington (Figure 1). The project area encompasses approximately 0.7 river miles of the Wenatchee River main stem, islands, side channels and adjacent floodplain located on land owned by the US Forest Service and one private landowner. The goal of this project is to increase instream complexity and off-channel habitat for Endangered Species Act (ESA) listed Chinook Salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*). This project area was originally identified in the Upper Wenatchee River Stream Corridor Assessment and Restoration Strategy (Assessment, Inter-Fluve, Inc. 2012).

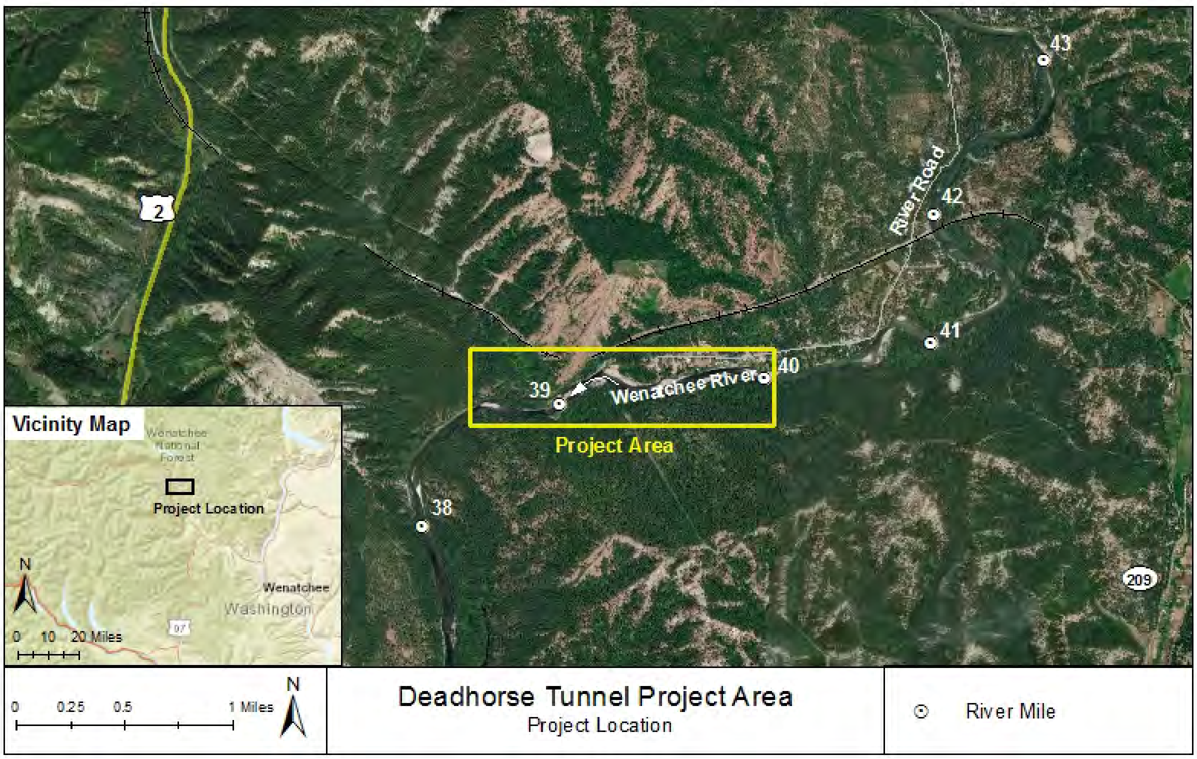

Figure 1. Project area locator map.

The Deadhorse Tunnel project area was included in Reach 3 of the Assessment. Within the project area, five subareas were identified in the Assessment and shown on Sheet 2 of the concept plans:

Subarea 1: RM 38.9 right bank – Deadhorse Island side-channel enhancement
Subarea 2: RM 39.0 left bank – Tunnel alcove enhancement
Subarea 3: RM 39.3 right bank – Roads End off-channel and main stem enhancement
Subarea 4: RM 39.4 left bank – Meander bend jams
Subarea 5: RM 39.6 left bank – Off-channel enhancement

1.1 NAME AND TITLES OF SPONSOR, FIRMS AND INDIVIDUALS RESPONSIBLE FOR DESIGN

The project is sponsored by the Yakama Nation. Inter-Fluve is the engineering design firm. Dan Miller (PE) is the licensed engineer of record, project manager and point of contact for this project. Mike Brunfelt (LG) is the project geomorphologist.

1.2 LIST OF PROJECT ELEMENTS THAT HAVE BEEN DESIGNED BY A LICENSED PROFESSIONAL ENGINEER

Dan Miller (PE) is the licensed engineer of record for this project for the current phase of concepts development. If Inter-Fluve is retained for future design contracts, Dan will remain the engineer of record. Project elements include the following, with BPA HIP III activity and risk category included:

Table 1. Activity categories and risk included in the Deadhorse Tunnel project.

Description of Proposed Enhancement	Work Element	HIP III Category	HIP III Risk Level
Log jam construction to improve mainstem and side channel habitat suitability and stability	Install habitat-forming natural material instream structures	2d	Low-Medium
Side channels and backwater alcove areas	Improve secondary channel and off channel refugia	2d, 2f	Medium
Revegetation of all disturbed surfaces	Riparian vegetation planting	9d,9c	Low

1.3 IDENTIFICATION AND DESCRIPTION OF RISK TO INFRASTRUCTURE OR EXISTING RESOURCES

As shown on Sheet 2 of the plans a number of residences and River Road exist along the river-right floodplain near the upstream end of the project. A few of the private landowners are participating in this concept development phase within Subarea 3. Other, non-participating properties will have no physical activity on their properties. During the design phase, impacts to water surface elevations for high flow events and potential changes in inundation limits will be modeled and evaluated. These properties exist upstream of much of the proposed concepts thus direct impacts pose low risk.

The next infrastructure downstream includes the WSDOT Highway 2 Bridge near the Tumwater campground approximately 3 river miles downstream. The Highway 2 Bridge is comprised of two long spans with one intermediate pier (Figure 2). The width of the spans exceed the length of logs anticipated to be used in the project. Risk to the bridge is considered to be low.

Figure 2. Highway 2 Bridge at head of Tumwater Canyon

1.4 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE – PERIOD) AND LIMITING FACTORS ADDRESSED BY THE PROJECT

Current fish use in the project area includes ESA-listed spring Chinook (endangered), steelhead (threatened), Bull Trout (*Salvelinus confluentus*, threatened), and non-listed summer Chinook Salmon, Coho Salmon (*O. kisutch*), Sockeye Salmon (*O. nerka*) and Westslope Cutthroat Trout (*O. clarkii*). The Upper Wenatchee River is a major spawning area for spring Chinook and steelhead, migration corridor for sockeye, spring Chinook, coho, steelhead, and bull trout, and a rearing and overwintering area for spring and summer Chinook Salmon, steelhead, and bull trout (UCRTT 2017). Past redd counts show small numbers of steelhead redds within the existing side channel within the project area (Figure 3).

Bull trout are known to occur in tributaries to the Wenatchee River, including the Chiwawa River, White River, Little Wenatchee River, Nason Creek, Chiwaukum Creek, Icicle Creek, Peshastin Creek, Negro Creek, and Ingalls Creek (UCSRB 2007). Bull trout may be present in the project area as they migrate to spawning grounds or overwintering areas, however heavy use of the project area is unlikely.

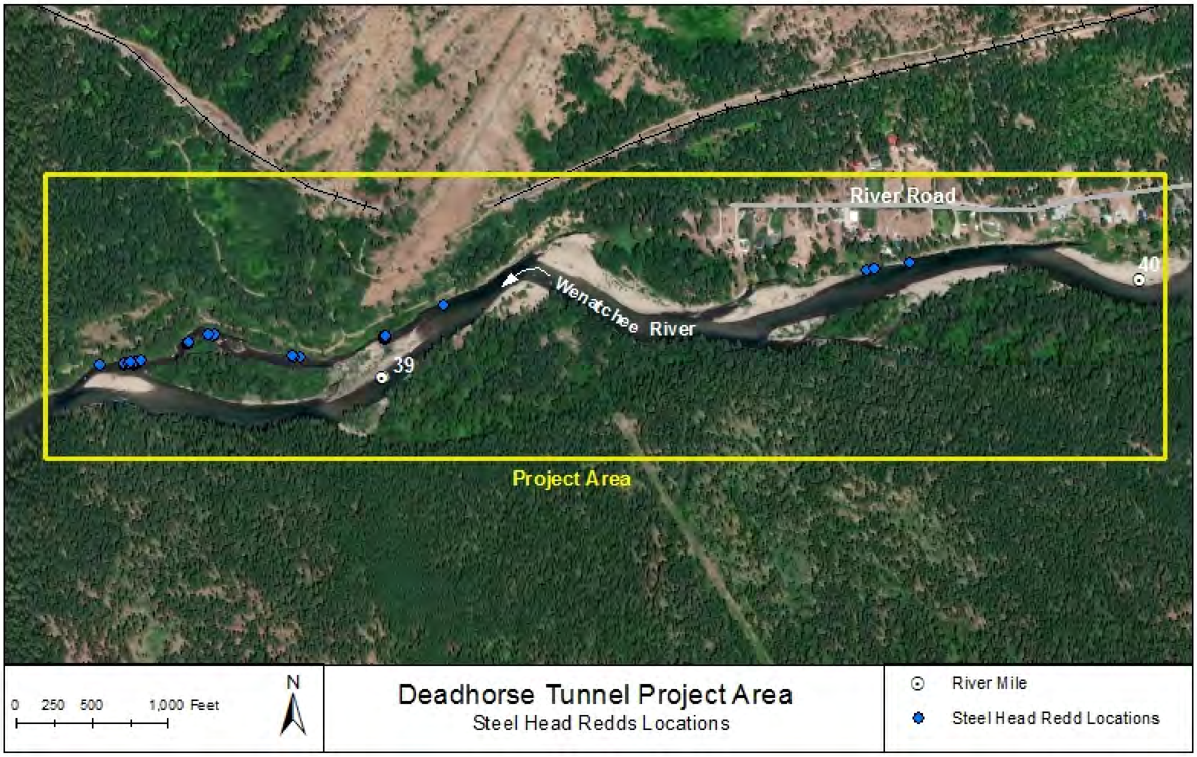

Figure 3. Steelhead redds recorded in the project area between 2011 – 2016. No Spring Chinook or Bull Trout redds have been observed in the project area. Redd data from Upper Columbia Salmon Recovery Board.

Spring Chinook and summer steelhead are therefore target species for this habitat enhancement project, and utilize the project area during different life stages year-round (Figure 4).

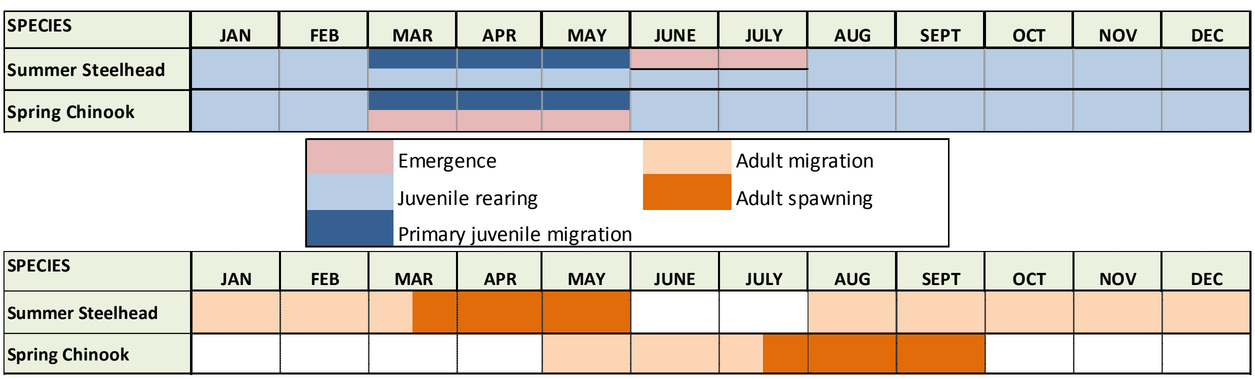

Figure 4. Life history timing of steelhead and Spring Chinook within the project area.

1.4.1 Steelhead

Adult steelhead enter the Wenatchee basin from August through April, holding in deep pools with overhead cover. Spawning begins in very late March, peaks in mid-April, and lasts through May. Egg survival is highly sensitive to intra-gravel flow and temperature (NWPCC 2004), and is particularly sensitive to siltation earlier in the incubation period (Healy 1991). Fry emerge from the redds 6-10 weeks after spawning (Peven 2003).

Age-0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover (Moyle et al. 2002, US Fish and Wildlife Service 1995). Age-0 steelhead use slower, shallower water than Chinook Salmon, preferring small boulder and large cobble substrate (Hillman et al. 1989). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate (US Fish and Wildlife Service 1995). Juveniles outmigrate between ages one and three, though some hold over and display a resident life history form. Smolts begin migrating downstream from natal areas in March (NWPCC 2004).

1.4.2 Chinook Salmon

Adult spring Chinook enter the Wenatchee in May, holding in deeper pools with overhanging cover until water temperatures are suitable for spawning. Spawning typically begins in very late July, peaks in late August, and ends in late September (NWPCC 2004). Eggs are very sensitive to changes in oxygen levels and percolation, both of which are affected by sediment deposition and siltation in the redd (Healy 1991, Peven 2003). Fry emerge in June and July, which coincides with the rising hydrograph, forcing juveniles to seek out backwater or margin areas with lower velocities, dense cover, and abundant food (Quinn 2005). Fry are extremely vulnerable when they emerge, because their swimming ability is poor and flows are high. Near-shore areas with eddies, large woody debris, undercut tree roots, and other cover are very important for post-emergent fry (Hillman et al. 1989, Healy 1991).

As they increase in size, juveniles begin to select for deeper and faster moving water, particularly areas with overhanging cover (Moyle et al 2002b). These areas provide more holding and feeding habitat area for the larger juveniles to occupy. Upper-Columbia spring Chinook express a stream-type life history, meaning they rear in freshwater for at least one year before outmigrating as yearlings. Smolts begin migrating in March from natal areas (NWPCC 2004).

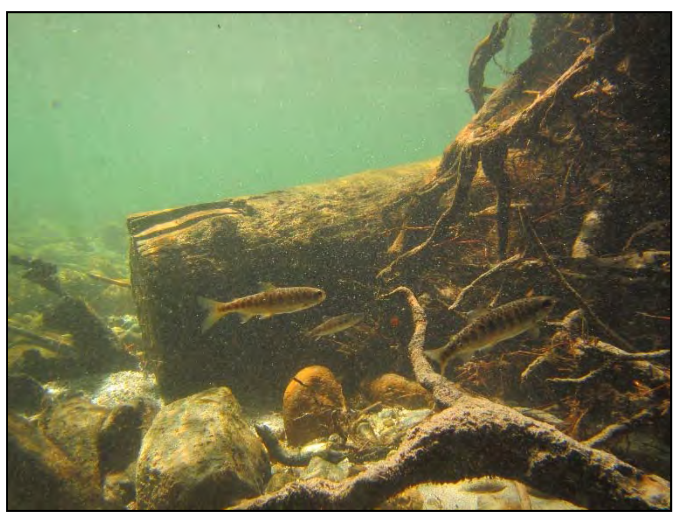

Figure 5. Chinook Salmon parr resting behind a constructed log jam in the Entiat River between feeding forays.

1.5 LIST OF PRIMARY PROJECT FEATURES INCLUDING CONSTRUCTED OR NATURAL ELEMENTS

Primary project features consist of the following:

- **Large wood installation**: Construct large wood structures with scour pools in the main stem and side channels of the Wenatchee River to provide complex holding and rearing habitat at a range of flow conditions.
- **Side channels and backwater alcove areas**: Created and enhanced perennial side channels and backwater alcove areas which may collect groundwater are included for off channel refugia. Large wood will be placed along the created and enhanced channels to provide overhead cover and complexity.
- **Riparian revegetation**: Plant native species in all disturbed areas to promote riparian function and increase food production and habitat complexity for target species.

Design elements have been developed for the five subareas within the project area as shown on Sheet 2 of the plans. The following sections describe conceptual design elements within each subarea.

1.5.1 Subarea 1: RM 38.9 right bank – Deadhorse Island side-channel enhancement

Subarea 1 includes an island and side channel complex within the river right floodplain. The upstream end of the island has a number of naturally occurring LWM accumulations. The side channel presents a great opportunity to add additional wood at several locations to encourage scour and provide overhead cover. There are two existing backwater alcoves on the island that could be enhanced through excavation. Concepts are shown on Sheets 3 and 4 of the plans.

Access to Subarea 1 is difficult, as no existing roads can be safely negotiated by construction equipment. LWM could be transported and staged by a helicopter moving wood from the Subarea 3 large gravel bar or the wood could be transported by ground based equipment requiring multiple channel crossings. HECRAS model results indicate that flow depths and velocities will require supplemental work with heavy equipment to provide a sufficient level of ballasting. Equipment access could occur by fording of the river or by placing two channel spanning bridges as shown on the plans. It should be noted that temporary bridges would each need to span approximately 125ft to 150ft to remain outside of low late summer flows; and would need to be longer to span higher early-mid summer flows. The temporary bridge installation will require short term impacts to the channel and disturbance of floodplain and riparian areas to setup and deploy the bridge.

Impacts to wetlands and permitting requirements would be examined more closely in the next design phase.

1.5.2 Subarea 2: RM 39.0 left bank – Tunnel alcove enhancement

Subarea 2 includes an existing high flow side channel and floodplain backwater/wetland area within the river left floodplain. Designs for this subarea include: 1) enhancing the side channel to be a perennial flow through side channel including an apex log jam and channel margin jams, 2) enhancing a backwater alcove to provide more frequent off channel habitat, and 3) a side channel from Subarea 4 across the river left floodplain. Concepts are shown on Sheet 5 of the plans.

Construction access will be challenging and would require either one channel spanning bridge approximately 150ft long to span low late summer flows, or staging LWM by helicopter and fording an excavator for supplemental placement. Excavated material from channel creation and enhancement would likely need to be hauled off site as the entire floodplain area is within the FEMA 100-year floodplain.

Impacts to wetlands and permitting requirements would be examined more closely in the next design phase.

1.5.3 Subarea 3: RM 39.3 right bank – Roads End side channel enhancement

Subarea 3 concepts were evaluated in 2013 by Inter-Fluve and have been updated as part of this study. Subarea 3 includes a large gravel/cobble bar on river right that is beginning to establish riparian vegetation with a side channel around the periphery. The floodplain area of Subarea 3 contains three relic channel features. Concepts are shown on Sheet 6 for enhancement of the peripheral channel around the bar as a perennial side channel and the three relic floodplain channels as backwater alcoves and groundwater channels. Sediment deposition is a concern and may limit the life expectancy of proposed habitat features. Access to the site is good and can follow existing roads and trails. The large gravel bar may serve as a log laydown area for dispersal to other project areas by helicopter. Groundwater gain along the alcove channels should be further studied by soil pits and deployment of water level data loggers to understand groundwater levels and potential flow rates into new channels. Impacts to wetlands and permitting requirements would be examined more closely in the next phase.

1.5.4 Subarea 4: RM 39.4 left bank – Meander bend jams

Subarea 4 includes the outside of bend left bank which is relatively active and migrating. Concepts include placing log jams along the river bank and connecting a side channel across the floodplain to Subarea 2 as already described. Concepts are shown on Sheet 5 of the plans. Access, wetland impacts, and excavated material disposal concerns discussed for Subarea 2 are applicable to Subarea 4 as well.

1.5.5 Subarea 5: RM 39.6 left bank – Off-channel enhancement

Subarea 5 includes an island, side channels and backwater alcove complex on river left. Private properties, homes, landscaping and bank armoring exist along river right opposite Subarea 5. There is an opportunity to enhance and create three side channels, one backwater alcove area and multiple LWM placements. Access to this site would require a temporary channel spanning bridge approximately 150ft long to span low late summer flows, or staging LWM by helicopter followed by equipment to finalize ballasting of LWM. Excavated material from channel enhancement and creation likely would need to be hauled off site as channel enhancements and floodplain are within the 100-year floodplain. Flood impacts will be more closely examined in the design phase. Impacts to wetlands and permitting requirements would be examined more closely in the next phase.

1.6 PERFORMANCE CRITERIA

1.6.1 Regional Habitat Objectives and Priorities

Regional objectives for salmonid habitat protection and restoration in the Upper Columbia Region have been evaluated and summarized in the document *A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region* (2014) by the Upper Columbia Salmon Recovery Board (UCSRB) Regional Technical Team (RTT). This Biological Strategy is part of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) and recommends region-wide biological considerations and approaches for salmonid habitat restoration and protection actions. The RTT guides the development and evaluation of salmonid recovery projects within the Upper Columbia Region.

The Biological Strategy has identified several assessment units within the major watersheds of the Upper Wenatchee River. The Deadhorse Tunnel project area falls within the Upper Wenatchee Assessment Unit, which was designated as a Tier 1 watershed of highest protection priority and Priority 2 for restoration actions. The RTT notes that in the Upper Wenatchee area there is the "potential for additional impacts," and that "increasing habitat complexity and additional floodplain connection may increase rearing (and potentially survival)" in the area (UCRTT 2017, Appendix E). The Upper Wenatchee River is a major spawning area for spring Chinook and steelhead, migration corridor for sockeye, spring Chinook, coho, steelhead, and bull trout, and a rearing and overwintering area for spring and summer Chinook Salmon, steelhead, and bull trout (UCRTT 2017).

For the Upper Wenatchee area, the RTT identifies the following ecological concerns and habitat action recommendations, in priority order:

1. Channel Structure and Form (Instream Structural Complexity)
    - Restore habitat diversity by enhancing large woody material recruitment, retention, and complexity
2. Peripheral and Transitional Habitat (Side Channel and Wetland Connections)
    - Improve fish access to oxbows and historical side channels that have been cut off from main channel
3. Riparian Condition (Riparian Condition)
    - River Road modification and relocation

1.6.2 Upper Wenatchee River Assessment

The RTT cites the Upper Wenatchee River Assessment (Inter-Fluve, 2012) for guidance on specific areas of restoration actions. Within the Upper Wenatchee River Assessment, the Deadhorse Tunnel site was included as part of Reach 3, where the following attributes were identified for restoration:

- Riparian condition

- Floodplain connectivity
- Bank condition/channel migration
- Pool depth and frequency
- Large wood and log jams
- Off-channel habitat enhancement

The restoration strategy outlined in the Assessment includes reducing impacts to riparian areas and floodplains from human development; enhancing or creating off-channel habitat; and increasing pools, cover, and complexity with wood pieces and log jams.

1.6.3 Project Objectives

Based on the above considerations, as well as on-site conditions, the following restoration objectives were developed for the project site:

- **Support mainstem rearing habitat** for Chinook salmon and steelhead by increasing cover and complexity. Accomplish this by placing large wood along the mainstem and island side channels to promote scour pools and cover for juvenile fish.
- **Increase off-channel habitat quantity, diversity, and complexity** for Chinook salmon and steelhead over a range of flows by enhancing existing floodplain habitats and creating new habitats. Accomplish this by:
    - Increasing the availability of new off-channel habitat features and enhancing existing features,
    - Providing a diverse array of habitats that will support multiple species and life-stages, including perennial flow-through side channels, high-flow off-channel habitats, and connected backwaters and floodplain wetlands,
    - Providing fish access over a range of seasonal flow conditions, and
    - Enhancing complexity with additions of large wood and riparian plantings
- **Protect and restore natural riparian and floodplain vegetation communities along the mainstem and within the off-channel areas**. Vegetation enhancement will improve water quality, provide channel margin complexity, and provide a source for future large wood recruitment.

1.7 CONSTRAINTS AND DESIGN CONSIDERATIONS

There are a number of land use constraints that have the potential to influence project designs. These will be addressed throughout the design process in coordination with appropriate stakeholders. Constraints and design considerations identified for the project area include the following;

- The riparian area along river right in the upstream portion of the project area contains privately owned residential properties. This residential fringe along the floodplain limits connectivity between the channel and floodplain. Impacts to the residential area will need to be avoided or minimized.
- It will be difficult for construction equipment to access much of the project reach. Wenatchee River heavy equipment crossings or up to three temporary bridges with spans ranging from 125ft to 150ft for low late summer flows will be required to access many project concepts. Helicopter large wood staging would reduce the number of river crossings if the project was completed with no temporary bridges.
- Field work for wetlands delineation was completed by Inter-Fluve in November, 2018. Preliminary wetlands boundaries are included on the concept plans and subject to change with completion of the wetlands delineation report and review by US Army Corps of Engineers. Impacts of project elements to wetlands will be assessed in future design phases and may constrain floodplain habitat features proposed in the conceptual designs.
- Sediment deposition has been observed along proposed side channels and at the mouths of backwater alcove areas. Sediment deposition could affect the degree of surface water connectivity between the mainstem and off-channel areas over time limiting service life of these features.
- High flow depths and energy will require ballasting of mainstem log jams by burial, vertical logs and possibly boulders if piles are likely to encounter bedrock before adequate ballast depth is reached. Bedrock exists nearby but its depth below the surface near concept work areas is not known. Equipment access will be required to ballast many of the log jams. Ballasting designs will occur in the next design phase. Conceptual plan and details for LWM placements will be fully vetted and revised as necessary during the design phase to achieve desired level of stability.
- High recreational boating use of the mainstem Wenatchee occurs. Risk is mitigated to some extent by long sight lines and gravel bar escape opportunities. A formal risk analysis will be completed in the design phase.

Figure 6. Wenatchee River looking upstream at RM 38.9 to 39.2. Inlet to Subarea 1 is in left foreground. Subarea 3 includes large gravel bar in background. Access would require crossing the river at the glide in the background and riffle in the middle ground as indicated by white arrows.

1.8 DESIGN CRITERIA

A suite of criteria has been developed to guide development of conceptual designs. Design criteria serve three primary purposes: 1) to clearly document and communicate specific project objectives and constraints, 2) to help inform and guide the design process so that objectives are met, and 3) provide a basis for future performance monitoring. The conceptual design criteria will be refined in future design phases. The design criteria are divided into 4 categories: habitat, geomorphology/hydrology, engineering and risk, and construction impacts.

1.8.1 Habitat

- Increase in-stream and floodplain habitat quality and quantity for juvenile steelhead and Chinook salmon rearing at a range of flows
- Design habitat elements that have low risk of creating fish passage barriers
- Promote natural habitat forming processes to the maximum extent practicable
- Increase frequency and magnitude of floodplain inundation

1.8.2 Geomorphology/hydrology

- Design channels and floodplains that are consistent with current and projected hydrologic and geomorphic regimes, including those affected by beaver activity
- Promote dynamic, habitat-forming processes
- Maintain sediment transport continuity of off-channel habitat features to maximize design life and reduce sediment in-filling

- Promote sediment sorting

1.8.3 Engineering and risk

- Manage potential risk to river users
- Do not increase flooding or erosion risk to public or private infrastructure
- Provide adequate ballasting of placed logs to withstand high flows

1.8.4 Construction impacts

- Minimize impacts to existing wetland habitat and riparian & mature vegetation
- Minimize construction disturbance
- Protect existing utilities
- Minimize disturbance to local landowners

1.9 DESCRIPTION OF DISTURBANCE INCLUDING TIMING AND AREAL EXTENT AND POTENTIAL IMPACTS ASSOCIATED WITH IMPLEMENTATION OF EACH ELEMENT

Project disturbance at the site will be from temporary access routes and excavation of each LWM structure and side channels and backwater alcove. Construction would occur during the in water work window of July 1 to August 15. Some mobilization and preparation may occur in June and site restoration into early September for areas outside of in water work areas. Vegetation would likely occur in the fall.

2. Resource inventory and evaluation

2.1 DESCRIPTION OF PAST AND PRESENT IMPACTS ON CHANNEL, RIPARIAN AND FLOODPLAIN CONNECTIONS.

Channel, riparian and floodplain impacts are described in the Assessment (Inter-Fluve, 2013).

2.2 INSTREAM FLOW MANAGEMENT AND CONSTRAINTS IN THE PROJECT REACH

Not applicable to this project.

2.3 DESCRIPTION OF EXISTING GEOMORPHIC CONDITIONS AND CONSTRAINTS ON PHYSICAL PROCESSES

2.3.1 Soils

Islands and floodplain areas of the Deadhorse tunnel reach of the upper Wenatchee River are comprised of a number of soils. The predominant soil types includes 1) Beverly gravelly fine sandy loam (Bg), 2) Riverwash (Rh), 3) Mippon very gravelly loamy fine sand (1 & 186), and 4) Mippon gravelly fine sandy loam (185). Valley walls are comprised of Nard sandy to silt loams (NaF, NaD, 200, & 201) and Blag-Cle Elum – Rock Outcrop Complex (45) (Figure 7. USDA NRCS 2016).

Figure 7. NRCS soils types within the Deadhorse Tunnel reach of the upper Wenatchee River (USDA NRCS 2016).

Substrates within the active channel range from imbricated large cobble/small boulder in high energy areas to deposits of sands and silts in low energy areas (Figure 8). The river right bank near the upstream end of project is hardened with riprap and stone barbs, while the right bank near RM 39.15 is hardened by colluvium from the Blag-Cle Elum – Rock Outcrop Complex.

Figure 8. Looking upstream RM 39.2 showing typical channel bed conditions in alluvial areas of the reach.

No subsurface information is available at this time. Site analyses at future design phases may include soil pits to assess subsurface sediment characteristics, and groundwater level sensors to evaluate groundwater hydrology.

2.3.2 Channel processes

The Wenatchee River within the project reach flows through a naturally partially-confined valley, bordered by low-elevation floodplains, moderately sloping banks, steep terrace banks (of the Blag-Cle Elum – Rock Outcrop Complex). The channel form is meandering with islands and side channels. The reach has an average gradient of 0.35%, and bed morphology is primarily pool-riffle with some riffle-glide units. The project reach has a number of islands with side channels and off-channel habitat and LWM.

Land use in Reach 3 is predominantly US Forest Service managed land along both sides of the river with some private residential property along river-right. Parcels are shown on Sheet 2 of the plans. Chelan PUD has an overhead transmission line that crosses the river in the middle of the study area. This line does not impact channel processes but will be a concern for ground and aerial construction methods. Near the upstream end of the project area, the right bank adjacent to private land contains riprap and barbs that deflect flow away from the bank. River Road parallels the channel from RM 39.4 to RM 41.9 on river-right through a residential area. Vegetation removal/alteration, home construction, and bank hardening material are prevalent along the upstream portion of the reach (Figure 9).

Figure 9. Wenatchee River looking upstream at RM 39.4 to 39.8 showing mainstem-island-side channel complex on river left and residences and bank armoring along river right, highlighted in red (Inter-Fluve drone image 9/20/2018).

2.3.3 Description of existing riparian condition and historical riparian impacts

Riparian conditions in the project area are generally good. The forest is a mixed-age stand of Ponderosa Pine, Douglas fir, willow, dogwood and cottonwood.

2.4 DESCRIPTION OF LATERAL CONNECTIVITY TO FLOODPLAIN AND HISTORICAL FLOODPLAIN IMPACTS

The upper Wenatchee River historically had high floodplain connectivity with multiple off-channel wetlands, alcoves, and channels. Over bank floods currently occur at the 2-year return discharge in Subareas 1, 2, 3 and 5. The Subarea 4 floodplain is inundated at the 5-year event.

2.5 TIDAL INFLUENCE IN PROJECT REACH AND INFLUENCE OF STRUCTURAL CONTROLS (DIKES OR GATES)

Not applicable to this project.

3. Technical data

3.1 INCORPORATION OF HIPIII SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

HIPIII conservation measures will be met through the project design and variances will be submitted for any conservation measures that cannot be met.

3.2 SUMMARY OF SITE INFORMATION AND MEASUREMENTS (SURVEY, BED MATERIAL, ETC) USED TO SUPPORT ASSESSMENT AND DESIGN

3.2.1 Elevation data

Survey data was collected by Inter-Fluve using Real Time Kinetic (RTK) GPS, total station and hydrolite echosounder equipment. Subarea 3 floodplain area topography was collected by Inter-Fluve on May 16, 2013. Mainstem and side channel topography and bathymetry for remaining areas were collected September 19-20, 2018. River flows recorded at the USGS gage at Plain were 9,680 cfs on May 15, 2013 and 345 cfs on September 19-20, 2018.

To translate the survey data to known horizontal and vertical datum, static data at the RTK GPS base station were collected and adjusted using the National Geodetic Survey's Online Positioning User Service. The surveyed data are referenced to the Washington State Plane North coordinate system with vertical datum of NAVD88.

3.3 SUMMARY OF HYDROLOGIC ANALYSES CONDUCTED, INCLUDING DATA SOURCES AND PERIOD OF RECORD INCLUDING A LIST OF DESIGN DISCHARGE (Q) AND RETURN INTERVAL (RI) FOR EACH DESIGN ELEMENT

The Upper Wenatchee River is a snowmelt-dominated system with low flows in late summer through winter, and high flows during snowmelt (Figure 10). The snowmelt runoff typically occurs during the spring and early summer, and is driven by changes in ambient air temperature, snowpack mass, and the elevational distribution of the season's snowpack (WDOE 1983). Peak runoff usually occurs from April through July, with the highest rates typically occurring in late June. The Wenatchee typically returns to base flows in September.

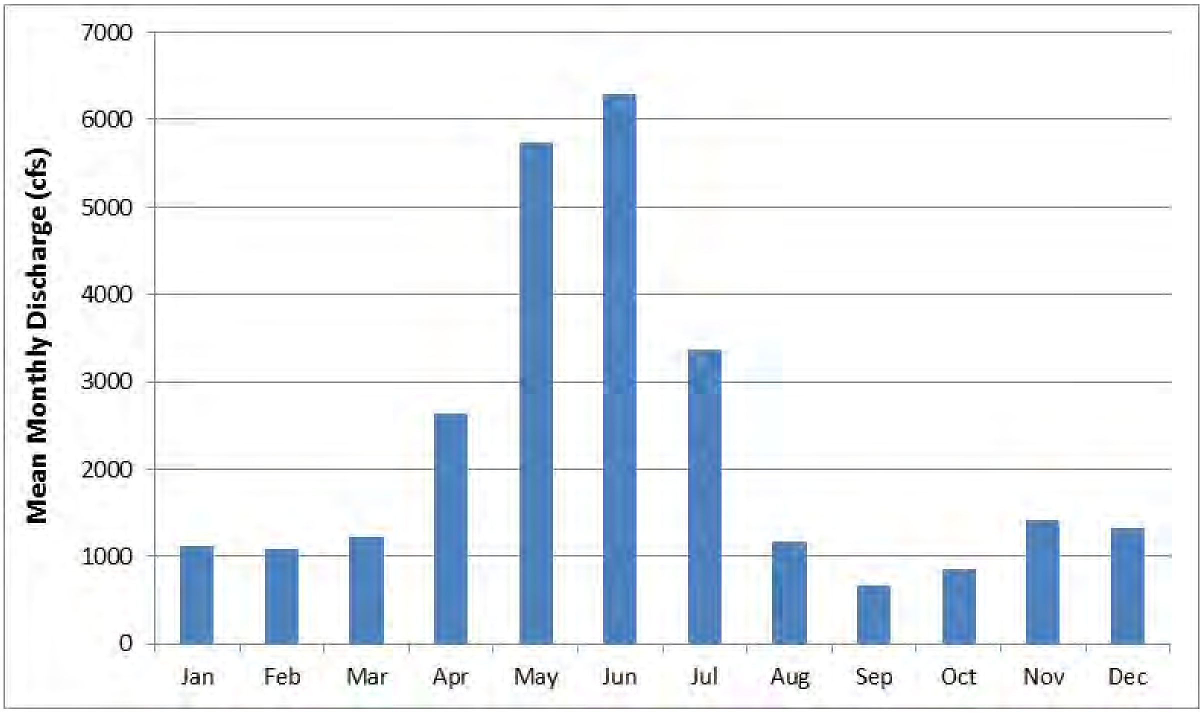

Figure 10. Mean monthly discharge for the period of record at the USGS gage at Plain, WA (Gage 12457000, 1911 to present).

The hydrology of the study area is significantly affected by Lake Wenatchee. Temporary storage in Lake Wenatchee buffers the snowmelt runoff signal from the Little Wenatchee and White River drainages, which contribute 40% of the total annual runoff to the Wenatchee River. As a result, runoff from some of the highest elevation, and highest precipitation regions of the basin are moderated by temporary storage in Lake Wenatchee. Below the lake, at river mile 53.6, Nason Creek contributes about 18% of the annual flow of the Wenatchee; at river mile 48.4, the Chiwawa River contributes about 15% of the annual flow of the Wenatchee. The USGS gage on the Wenatchee at Plain (#12457000) is located approximately 5.5 miles upstream of the Deadhorse Tunnel project reach and has a record of data from 1911. The following table summarizes flows used in the project design.

Table 2. Flood frequency data used in the hydraulic model from data collected at the USGS Gage at Plain (Gage #12457000). Discharge units at each reach are cubic feet per second (cfs).

Flood Recurrence Interval	Discharge at Meacham Flats (cfs)
2	11,683
5	15,827
10	18,764
25	21,728
50	25,799
100	29,045

3.4 SUMMARY OF SEDIMENT SUPPLY AND TRANSPORT ANALYSES CONDUCTED, INCLUDING DATA SOURCES INCLUDING SEDIMENT SIZE GRADATION USED IN STREAMBED DESIGN

Substrate size data at this conceptual phase was limited to observations and photographs. Future design phases will include pebble counts. Channel design will include sediment mobility and channel stability calculations for design of channel dimensions, bed forms and substrate and bank vegetation types.

3.5 SUMMARY OF HYDRAULIC MODELING OR ANALYSES CONDUCTED AND OUTCOMES – IMPLICATIONS RELATIVE TO PROPOSED DESIGN

Existing channel and floodplain hydraulics were simulated using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 5.0.5; USACE 2018). HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program was run in two-dimensional mode. The hydraulic model calculates channel and floodplain water surface elevations, velocities, depths, and shear stresses and shows complex flow paths. Graphics of depths and velocities for the 1.5- and 100-year events are included in the appendices.

The model geometry was developed from topography and bathymetry surveys completed by Inter-Fluve for the mainstem, side channels and Subarea 3 floodplain. Topography for other floodplain areas was obtained from Chelan 2015 LiDAR. Values for Manning's n coefficient of hydraulic roughness were based on professional judgment and set at 0.08 for forests, 0.075 for islands, 0.045 for side channels and 0.038 for mainstem.

In addition to the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval floods, several flows below the 2-year event were modeled. The HECRAS model included a synthesized hydrograph that included steps with increasing discharge from low flows to the 100-year event. The duration of the flow steps was long enough for flow to transit the 2D mesh and stabilize before progressing to the next flow step. An upstream boundary condition was defined as the inflow hydrograph. The downstream boundary condition was set as a normal depth water surface elevation based on estimated profile slope.

A proposed conditions model will be constructed in the design phase.

The project is located within the FEMA flood insurance rate map community panel 530015 0775-B dated June 5, 1989. The 100-year inundation spans the full width of floodplain within the project area.

3.6 STABILITY ANALYSES AND COMPUTATIONS FOR PROJECT ELEMENTS, AND COMPREHENSIVE PROJECT PLAN

Stability analysis and computations for project elements will follow professional practice guidelines for large wood design (Knutson et. al. 2014 and USBR/ERDC 2016), stream habitat restoration (Cramer 2012), and institutional knowledge combined with professional judgment for the design of specific project elements. Detailed stability analysis and computations for project elements will be provided in subsequent design phases.

3.7 DESCRIPTION OF HOW PRECEDING TECHNICAL ANALYSIS HAS BEEN INCORPORATED INTO AND INTEGRATED WITH THE CONSTRUCTION – CONTRACT DOCUMENTATION

The results of the existing conditions model were used to identify candidate side channels alignments and backwater alcove areas. Inundation patterns, depths, velocities and flow paths were used to identify LWM placement locations. During the design phase, proposed conditions HECRAS model runs will be developed and iterated to refine channel geometry and perform ballasting and channel stability calculations for LWM.

3.8 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A LONGITUDINAL PROFILE OF THE STREAM CHANNEL THALWEG FOR 20 CHANNEL WIDTH UPSTREAM AND DOWNSTREAM OF THE STRUCTURE SHALL BE USED TO DETERMINE THE POTENTIAL FOR CHANNEL DEGRADATION

Not applicable to this project.

3.9 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A MINIMUM OF THREE CROSS-SECTIONS – ONE DOWNSTREAM OF THE STRUCTURE, ONE THROUGH THE RESERVOIR AREA UPSTREAM OF THE STRUCTURE, AND ONE UPSTREAM OF THE RESERVOIR AREA OUTSIDE OF THE INFLUENCE OF THE STRUCTURE) TO CHARACTERIZE THE CHANNEL MORPHOLOGY AND QUANTIFY THE STORED SEDIMENT

Not applicable to this project.

4. Construction – contract documentation

4.1 INCORPORATION OF HIPIII GENERAL AND CONSTRUCTION CONSERVATION MEASURES

General and construction conservation measures will be included in the stamped construction drawing set submittal at a later date.

4.2 DESIGN – CONSTRUCTION PLAN SET INCLUDING BUT NOT LIMITED TO PLAN, PROFILE, SECTION AND DETAIL SHEETS THAT IDENTIFY ALL PROJECT ELEMENTS AND CONSTRUCTION ACTIVITIES OF SUFFICIENT DETAIL TO GOVERN COMPETENT EXECUTION OF PROJECT BIDDING AND IMPLEMENTATION

Concept drawings are included. Future phases of the project will include preliminary and final construction drawings which will include plan, profile, section and detail sheets that identify all project elements and construction activities of sufficient detail to govern competent execution of project bidding and implementation.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES

To be included in future design phases.

4.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES THAT WILL BE IMPLEMENTED AND IMPLEMENTATION RESOURCE PLANS INCLUDING:

The following will be included in the final construction drawings:

- Site access staging and sequencing plan
- Work area isolation and dewatering plan
- Erosion and pollution control plan
- Site reclamation and restoration plan
- List of proposed equipment and fuels management plan

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES

A construction timeframe has not been determined at this time.

4.6 SITE OR PROJECT SPECIFIC MONITORING TO SUPPORT POLLUTION PREVENTION AND/OR ABATEMENT

Standard erosion and pollution control measure will be shown and detailed in the stamped construction drawing set.

5. Monitoring and adaptive management plan

The monitoring and adaptive management plan will be determined at the discretion of Yakama Nation Fisheries in subsequent design phases.

6. References

Andonaegui, C. 2001. Salmon, Steelhead, and Bull Trout Habitat Limiting Factors: for the Wenatchee Subbasin (Water Resource Inventory Area 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages) Final Report. WA State Conservation Commission: Olympia, WA. 347 pp. <http://www.fws.gov/pacific/fisheries/reportpub/index.cfm>.

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Healey, M. C. 1991. Life history of chinook salmon (Oncorhynchus tshawytscha). Pages 313-393 IN: C. Groot and L. Margolis, Editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, Canada.

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Moyle P. 2002. Salmon and Trout, Salmonidae – Rainbow Trout, (*Oncorhynchus mykiss*) *in* Inland Fishes of California. Los Angeles, California: University of California Press, 271-282.

Moyle P. 2002b. Salmon and Trout, Salmonidae - Chinook Salmon, (Oncorhynchus tshawytscha) in Inland Fishes of California. Los Angeles, California: University of California Press, 251-263.

Northwest Power and Conservation Council (NWPCC). 2004. Wenatchee Subbasin Plan. May 28, 2004. Pages 1-394.

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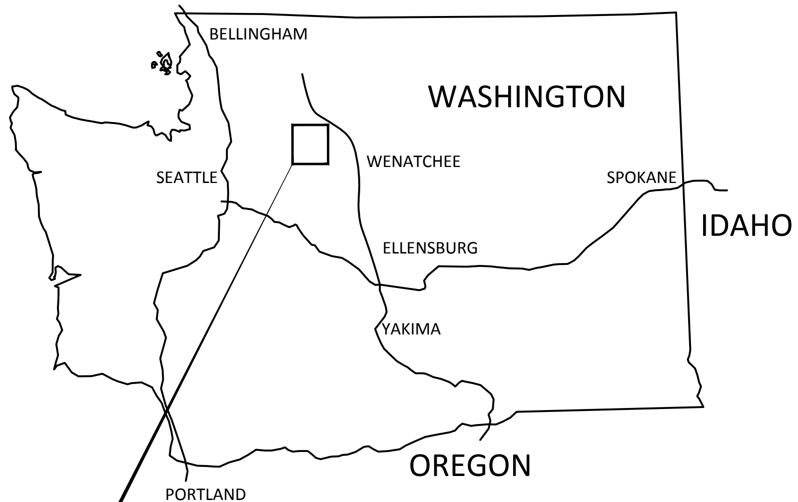
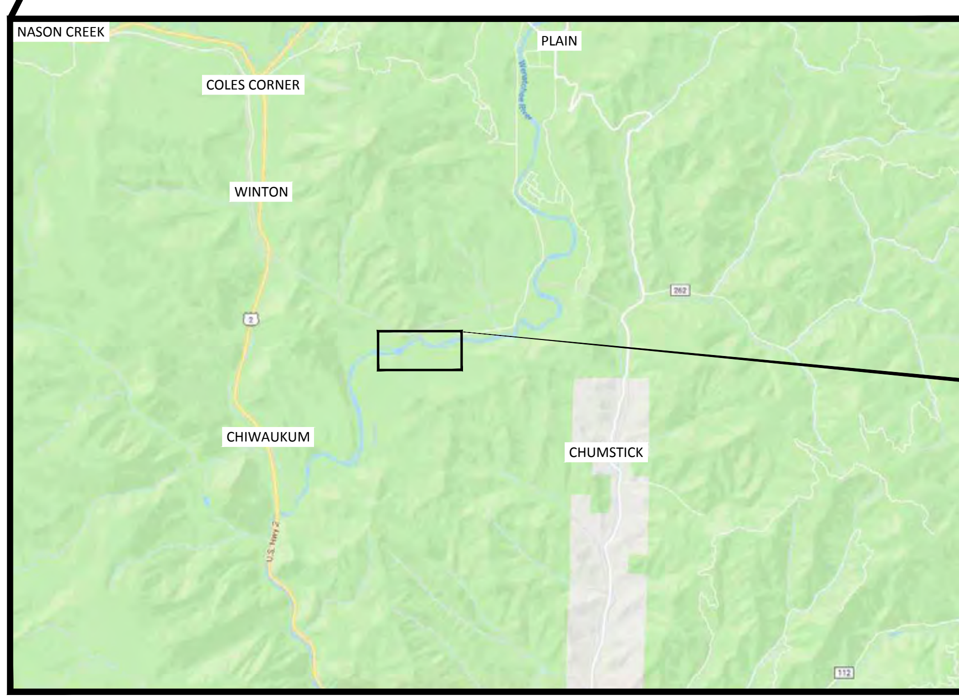
United States Geological Survey. 2016. StreamStats Program. http://water.usgs.gov/osw/streamstats/

USDA-NRCS (United States Department of Agriculture – Natural Resources Conservation Service) National Cooperative Soil Survey. Official Soil Series Descriptions. http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/home/?cid=nrcs142p2_053587.

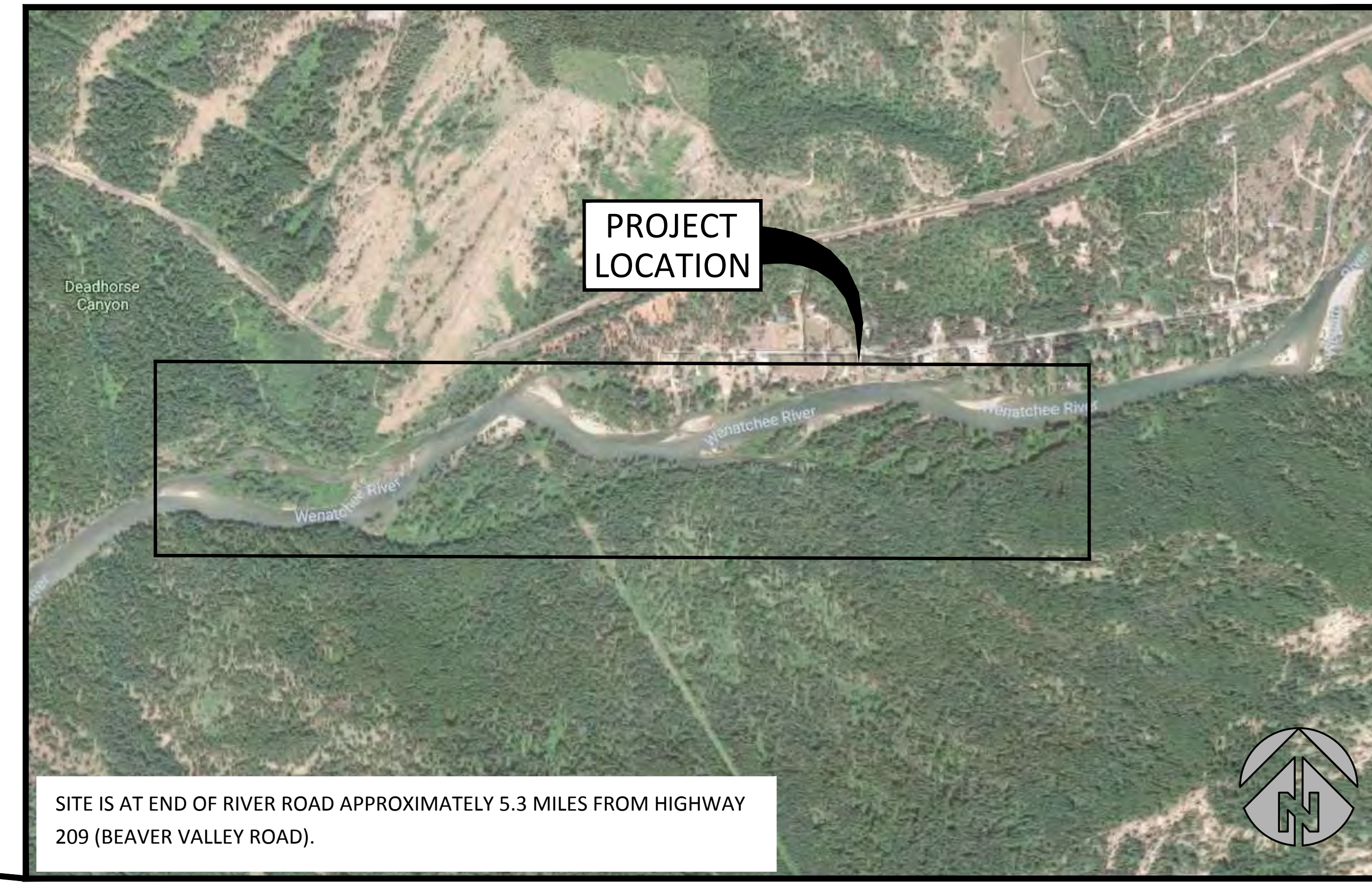
DEADHORSE TUNNEL PHASE 1 & 2
UPPER WENATCHEE RIVER, RIVER ROAD
CONCEPT LEVEL DESIGN, DECEMBER 17, 2018



LOCATION MAP
STATE OF WASHINGTON



VICINITY MAP
NOT TO SCALE



SITE MAP
NOT TO SCALE

SHEET INDEX

COORDINATES:
LATITUDE: 47.708510
LONGITUDE: -120.694478

SECTION 34, TOWNSHIP 26N, RANGE 17E

WATERBODY: WENATCHEE RIVER
TRIBUTARY OF: COLUMBIA RIVER

CONCEPTS

CONCEPTS FOLLOW HABITAT ENHANCEMENT OPPORTUNTIES IDENTIFIED IN "UPPER WENATCHEE RIVER STREAM CORRIDOR ASSESSMENT AND HABITAT RESTORATION STRATEGY" INTER-FLUVE, AUGUST 2012.

NO.	BY	DATE	REVISION DESCRIPTION

GS	DM	DM
DRAWN	DESIGNED	CHECKED
DM	12/17/18	18-02-17
APPROVED	DATE	PROJECT

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CONF. TRIBES & BANDS OF YAKAMA NATION

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TITLE SHEET

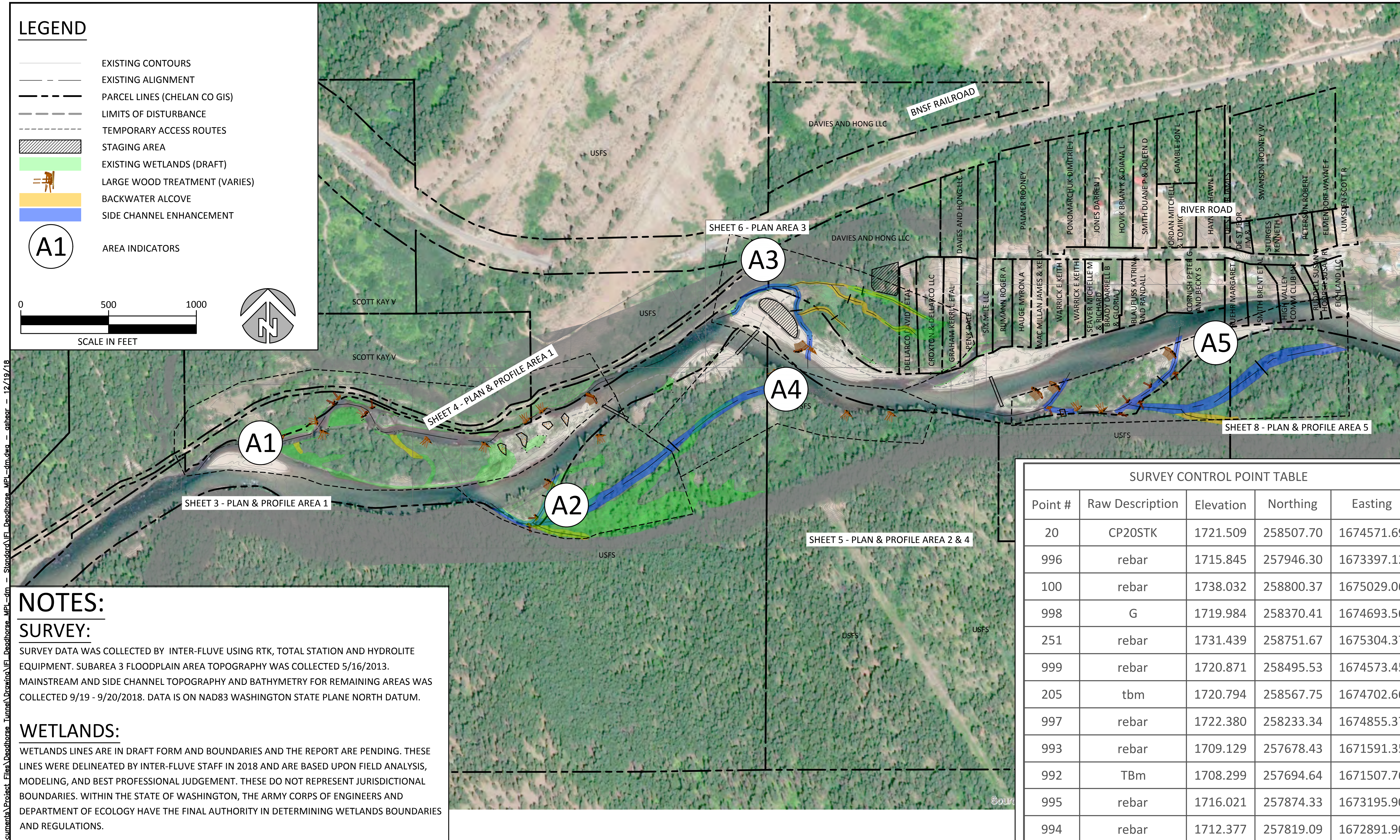
SHEET 1 OF 12

LEGEND

- EXISTING CONTOURS
- EXISTING ALIGNMENT
- PARCEL LINES (CHELAN CO GIS)
- LIMITS OF DISTURBANCE
- TEMPORARY ACCESS ROUTES
- STAGING AREA
- EXISTING WETLANDS (DRAFT)
- LARGE WOOD TREATMENT (VARIES)
- BACKWATER ALCOVE
- SIDE CHANNEL ENHANCEMENT
- A1 — AREA INDICATORS

0 500 1000

SCALE IN FEET



NOTES:

SURVEY:

SURVEY DATA WAS COLLECTED BY INTER-FLUVE USING RTK, TOTAL STATION AND HYDROLITE EQUIPMENT. SUBAREA 3 FLOODPLAIN AREA TOPOGRAPHY WAS COLLECTED 5/16/2013. MAINSTREAM AND SIDE CHANNEL TOPOGRAPHY AND BATHYMETRY FOR REMAINING AREAS WAS COLLECTED 9/19 - 9/20/2018. DATA IS ON NAD83 WASHINGTON STATE PLANE NORTH DATUM.

WETLANDS:

WETLANDS LINES ARE IN DRAFT FORM AND BOUNDARIES AND THE REPORT ARE PENDING. THESE LINES WERE DELINEATED BY INTER-FLUVE STAFF IN 2018 AND ARE BASED UPON FIELD ANALYSIS, MODELING, AND BEST PROFESSIONAL JUDGEMENT. THESE DO NOT REPRESENT JURISDICTIONAL BOUNDARIES. WITHIN THE STATE OF WASHINGTON, THE ARMY CORPS OF ENGINEERS AND DEPARTMENT OF ECOLOGY HAVE THE FINAL AUTHORITY IN DETERMINING WETLANDS BOUNDARIES AND REGULATIONS.

SURVEY CONTROL POINT TABLE

Point #	Raw Description	Elevation	Northing	Easting
20	CP20STK	1721.509	258507.70	1674571.69
996	rebar	1715.845	257946.30	1673397.12
100	rebar	1738.032	258800.37	1675029.06
998	G	1719.984	258370.41	1674693.56
251	rebar	1731.439	258751.67	1675304.37
999	rebar	1720.871	258495.53	1674573.45
205	tbm	1720.794	258567.75	1674702.66
997	rebar	1722.380	258233.34	1674855.37
993	rebar	1709.129	257678.43	1671591.35
992	TBm	1708.299	257694.64	1671507.76
995	rebar	1716.021	257874.33	1673195.90
994	rebar	1712.377	257819.09	1672891.90

NO.	BY	DATE	REVISION DESCRIPTION

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DM APPROVED	12/11/18 DATE	18-02-17 PROJECT

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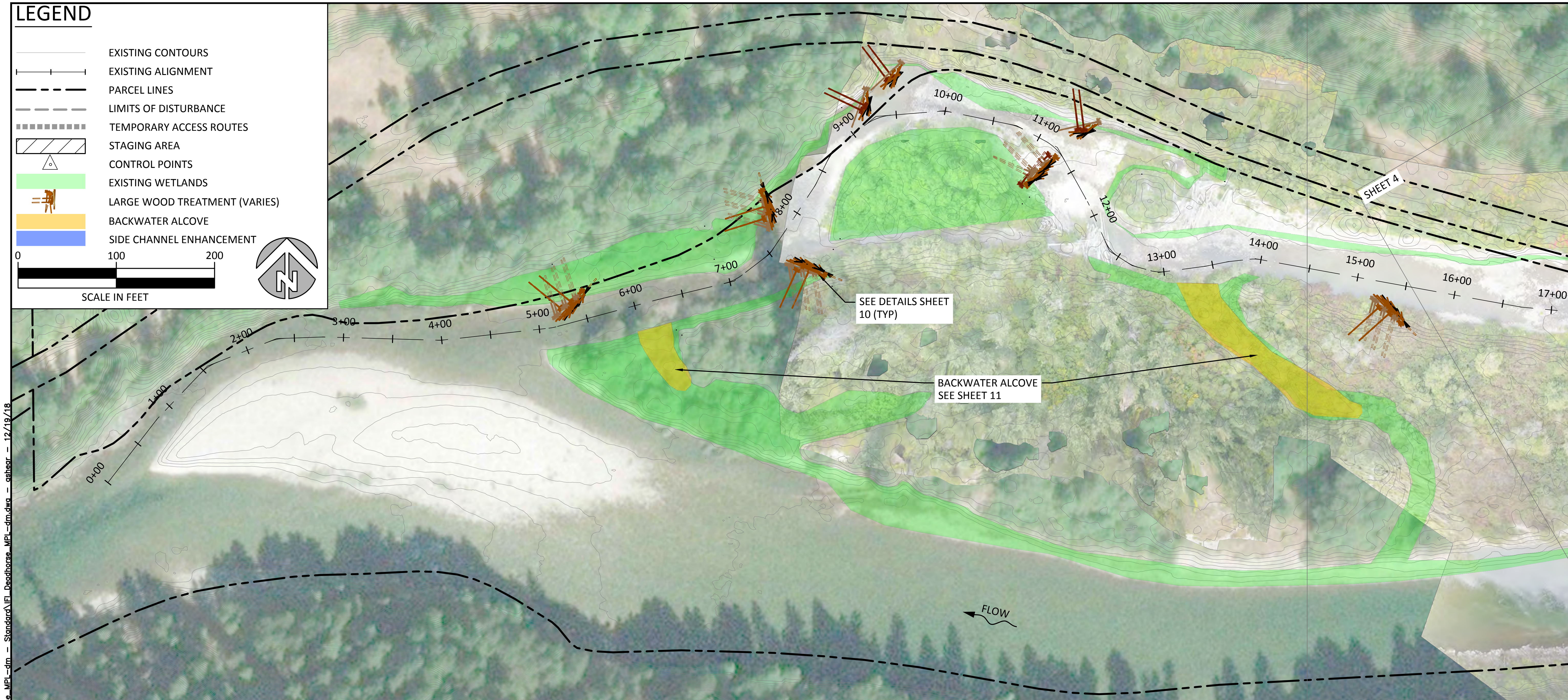
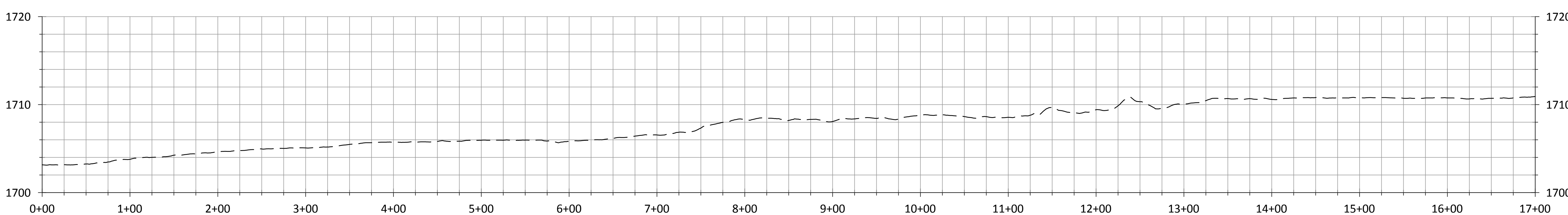
OVERVIEW





Side Channel 1

NO.	BY	DATE	REVISION DESCRIPTION

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DRAWN	DESIGNED	CHECKED
DM	12/11/18	18-02-17
APPROVED	DATE	PROJECT

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PLAN & PROFILE AREA 1

SHEET
3 OF 12

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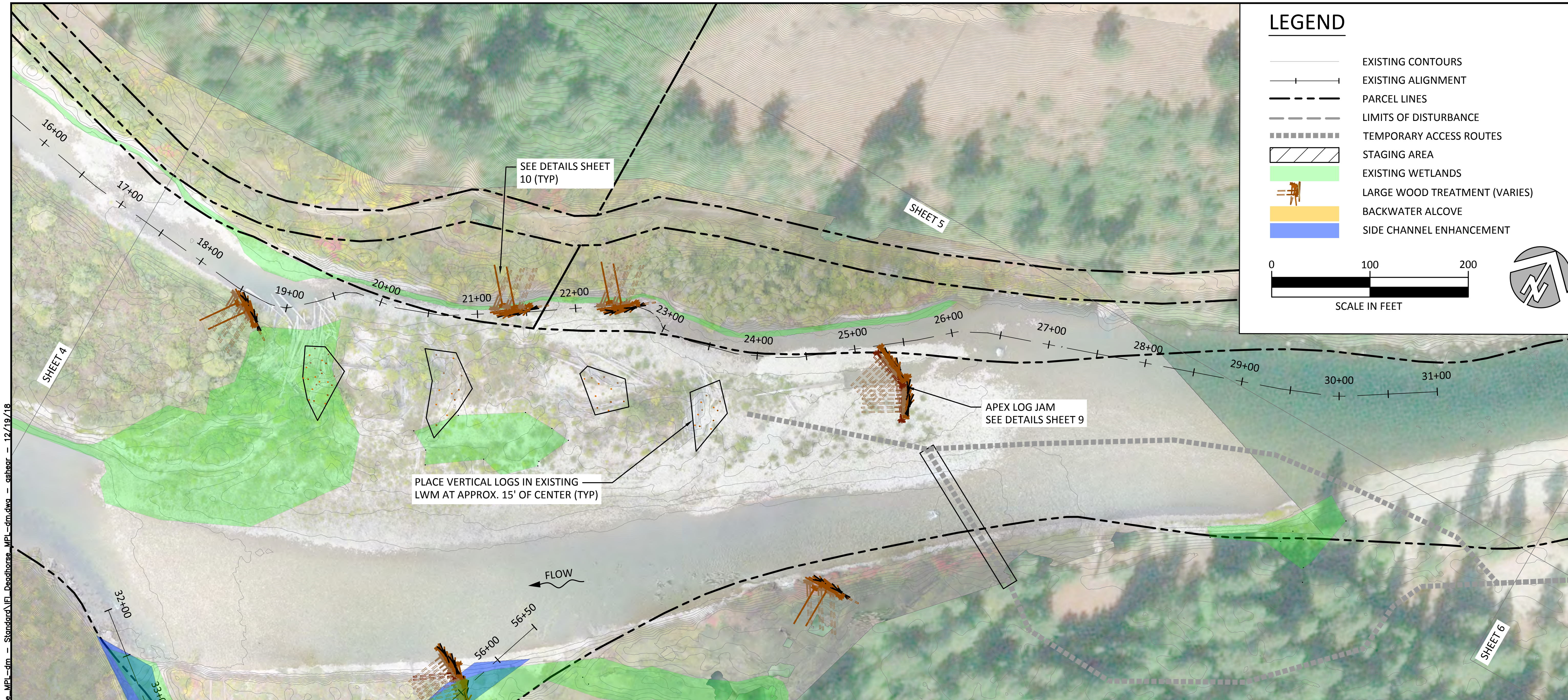

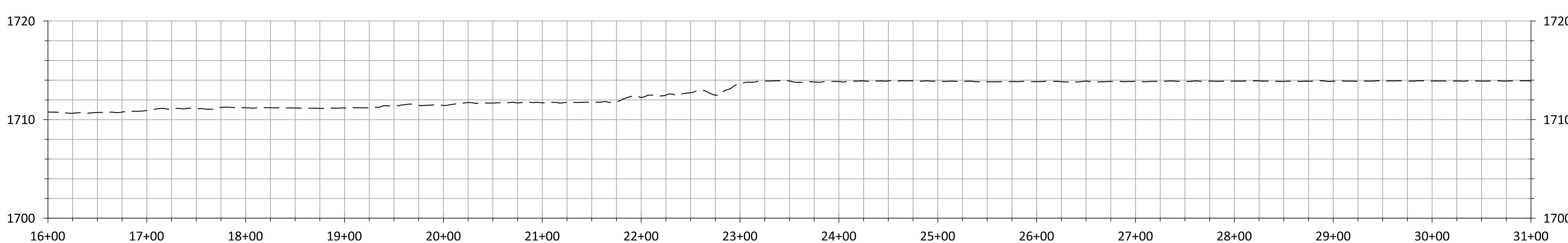

Side Channel 1

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NO.	BY	DATE	REVISION DESCRIPTION

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DM	12/11/18	18-02-17
APPROVED	DATE	PROJECT

DEADHORSE TUNNEL PHASE 1 & 2
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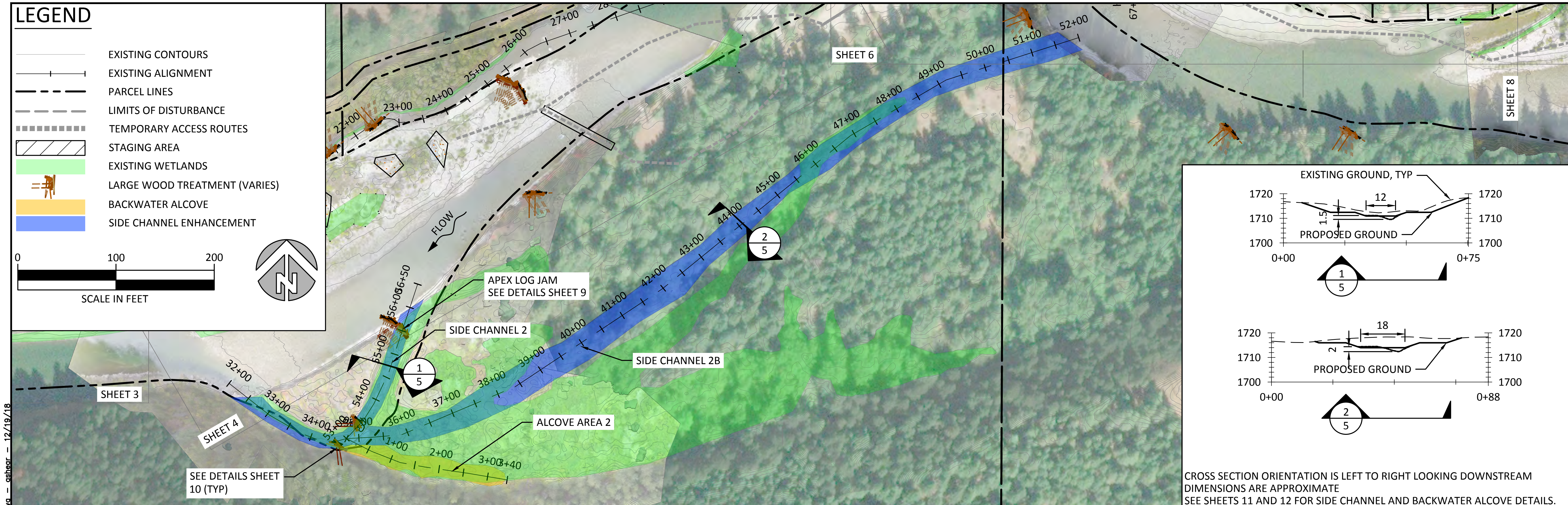
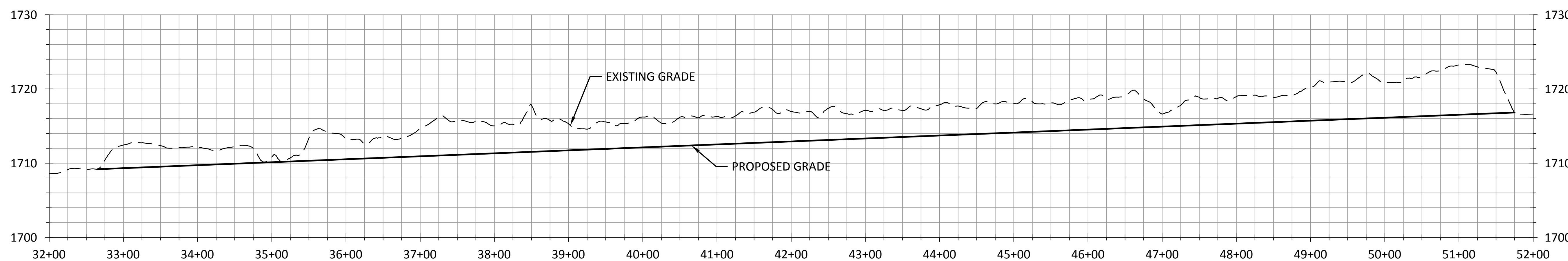
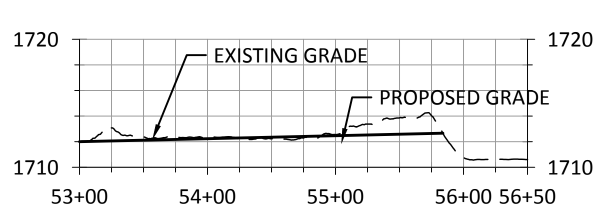
PLAN & PROFILE AREA 1

SHEET 4 OF 12

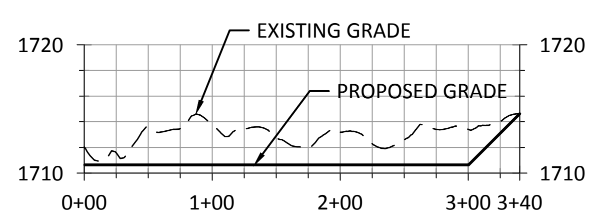




Side Channel 2B



Side Channel 2



Alcove Area 2

NO.	BY	DATE	REVISION DESCRIPTION

GS (DRAWN)	DM (DESIGNED)	DM (CHECKED)
DM (APPROVED)	12/11/18 (DATE)	18-02-17 (PROJECT)

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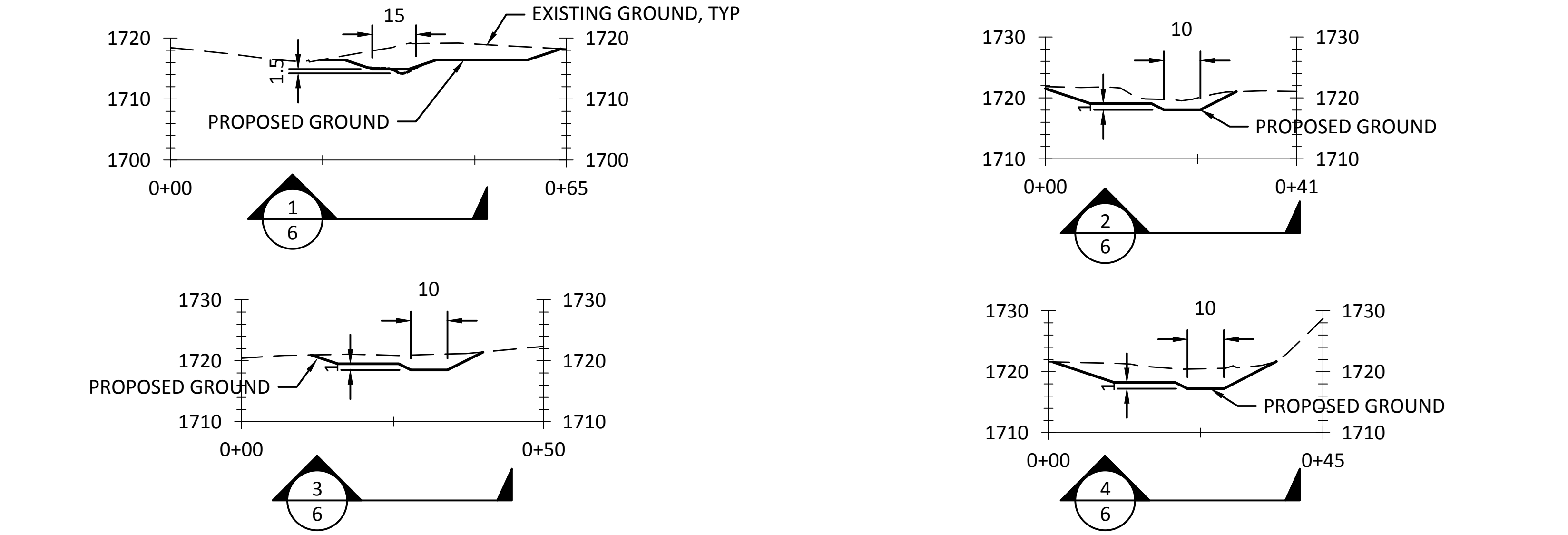
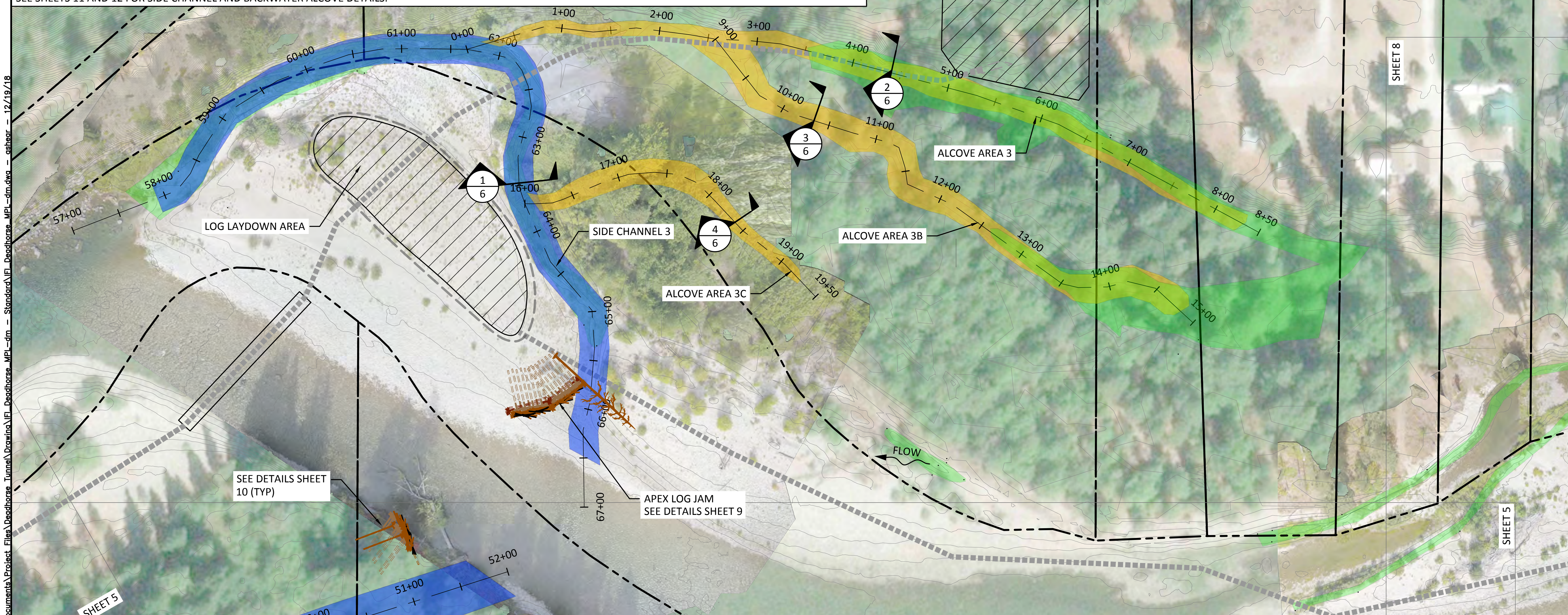
PLAN & PROFILE AREA 2 & 4

SHEET 5 OF 12



CROSS SECTION ORIENTATION IS LEFT TO RIGHT LOOKING DOWNSTREAM
DIMENSIONS ARE APPROXIMATE
SEE SHEETS 11 AND 12 FOR SIDE CHANNEL AND BACKWATER ALCOVE DETAILS.



LEGEND

EXISTING CONTOURS
EXISTING ALIGNMENT
PARCEL LINES
LIMITS OF DISTURBANCE
TEMPORARY ACCESS ROUTES
STAGING AREA
EXISTING WETLANDS
LARGE WOOD TREATMENT (VARIES)
BACKWATER ALCOVE
SIDE CHANNEL ENHANCEMENT

0 100 200
SCALE IN FEET

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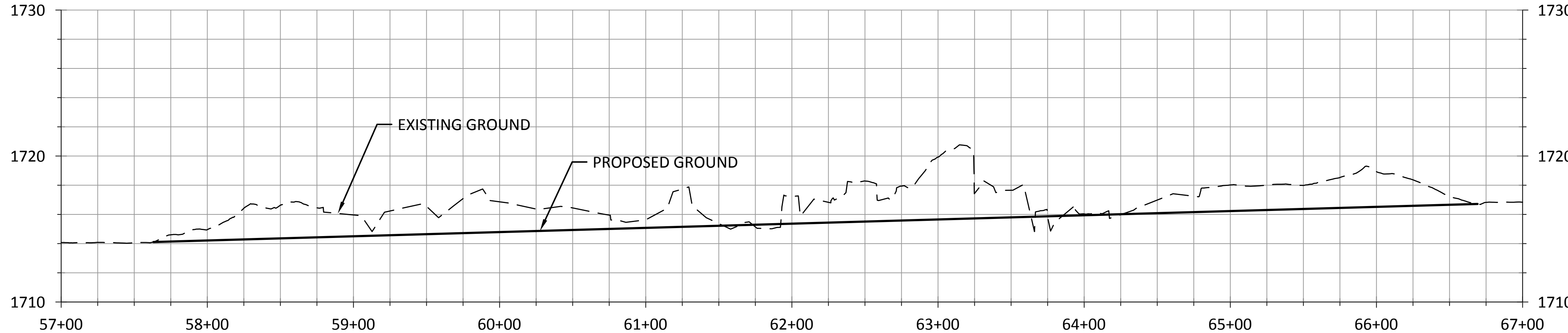
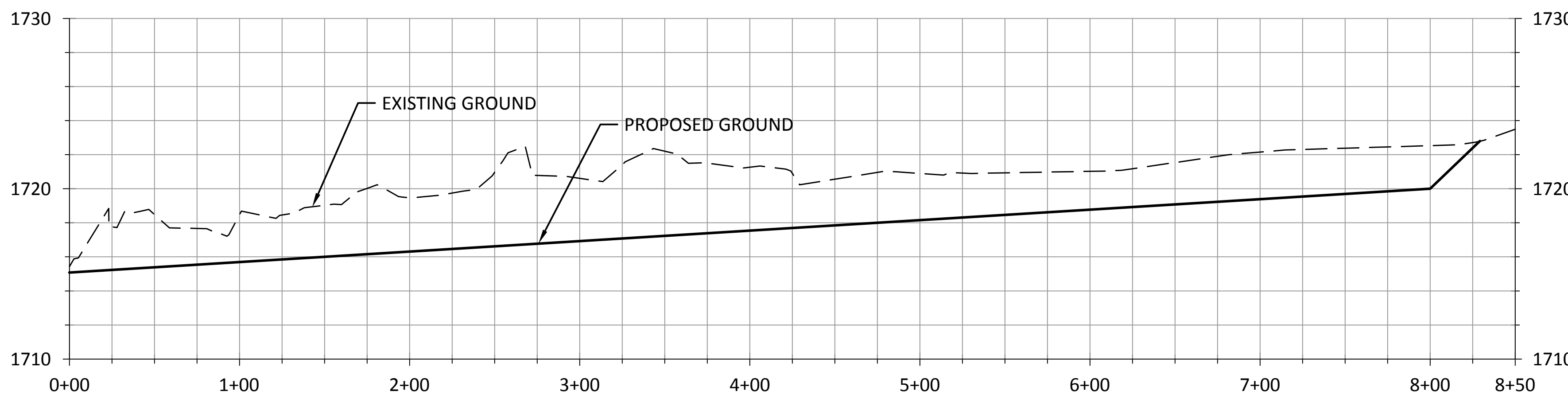
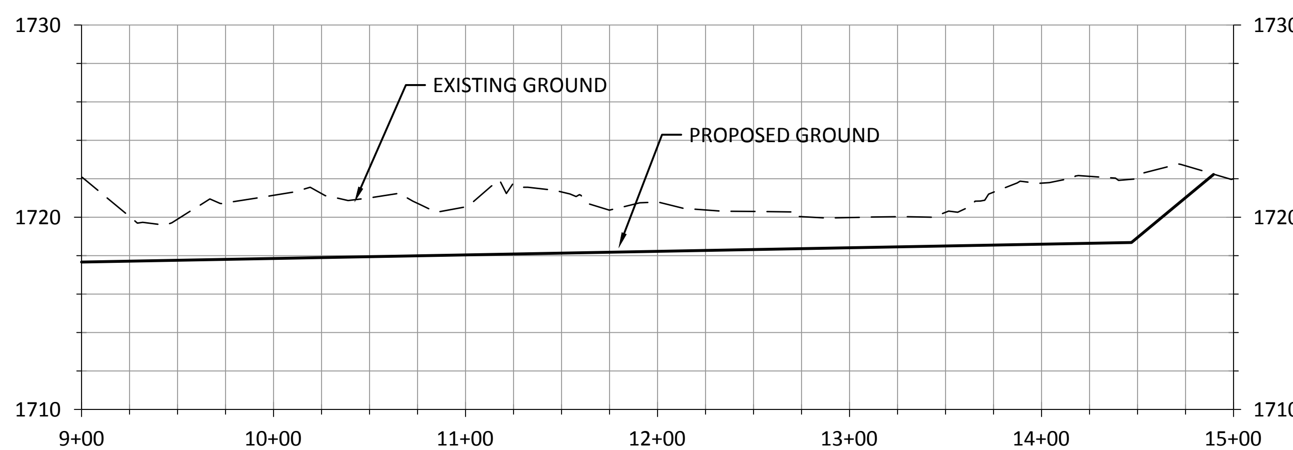
PLAN AREA 3



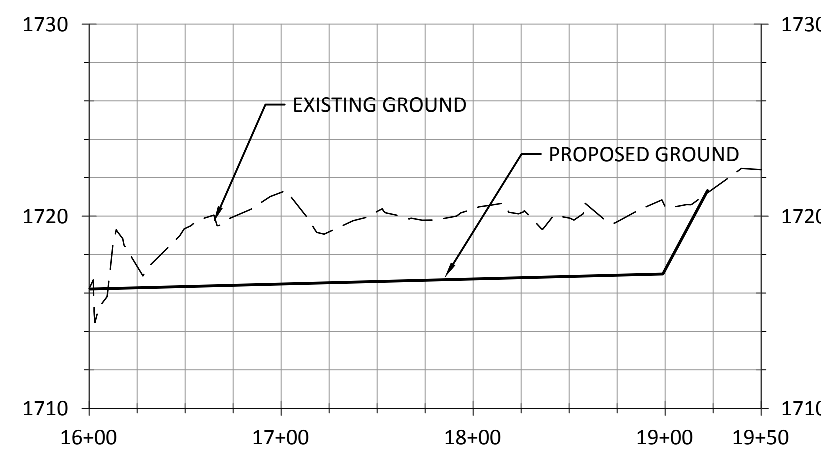
Side Channel 3



Alcove Area 3



Alcove Area 3B



Alcove Area 3C

SEE SHEETS ## AND 12 FOR SIDE CHANNEL
AND BACKWATER ALCOVE DETAILS.

NO.	BY	DATE	REVISION DESCRIPTION

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APPROVED	DATE	PROJECT

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PROFILE AREA 3

SHEET
7 OF 12

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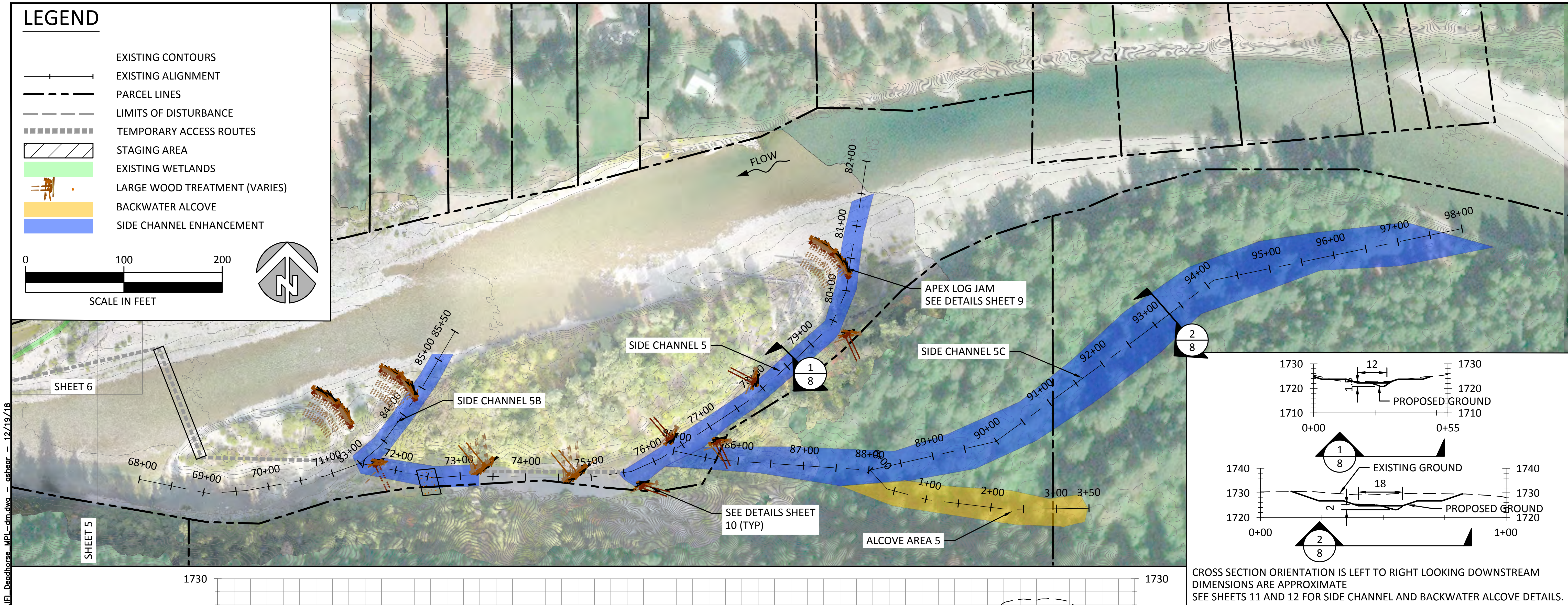
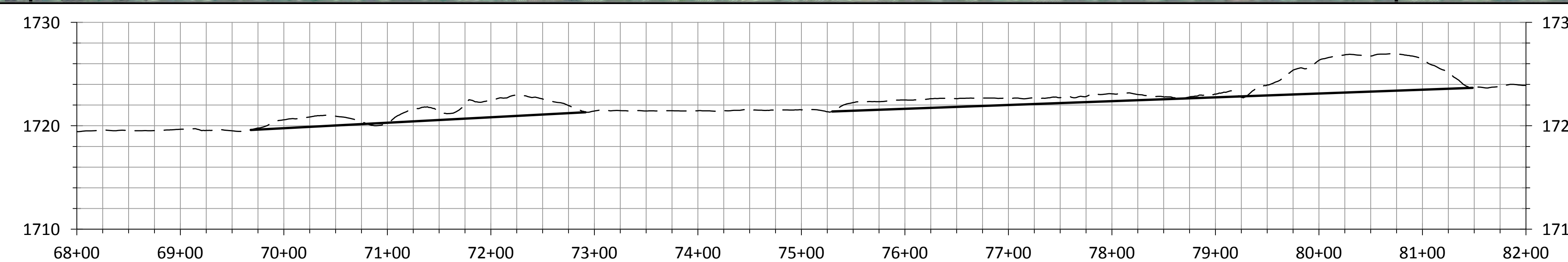
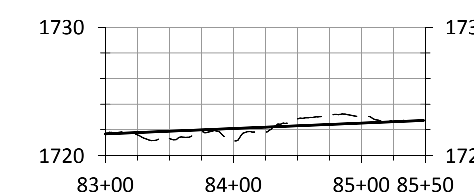
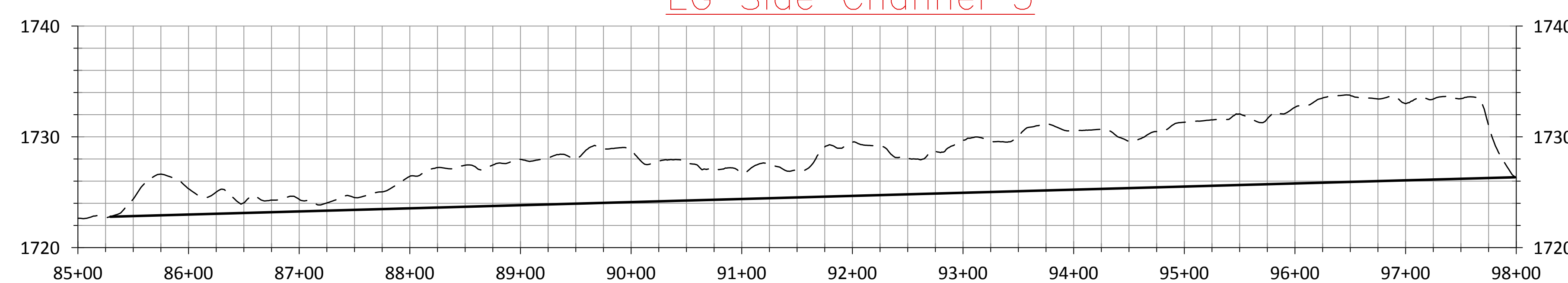




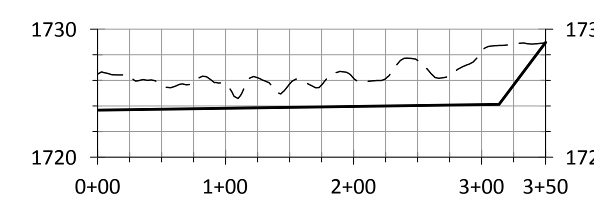
EG Side Channel 5



EG Side Channel 5B



EG Side Channel 5C



Alcove Area 5

NO.	BY	DATE	REVISION DESCRIPTION

GS	DM	DM
DRAWN	DESIGNED	CHECKED
DM	12/11/18	18-02-17
APPROVED	DATE	PROJECT

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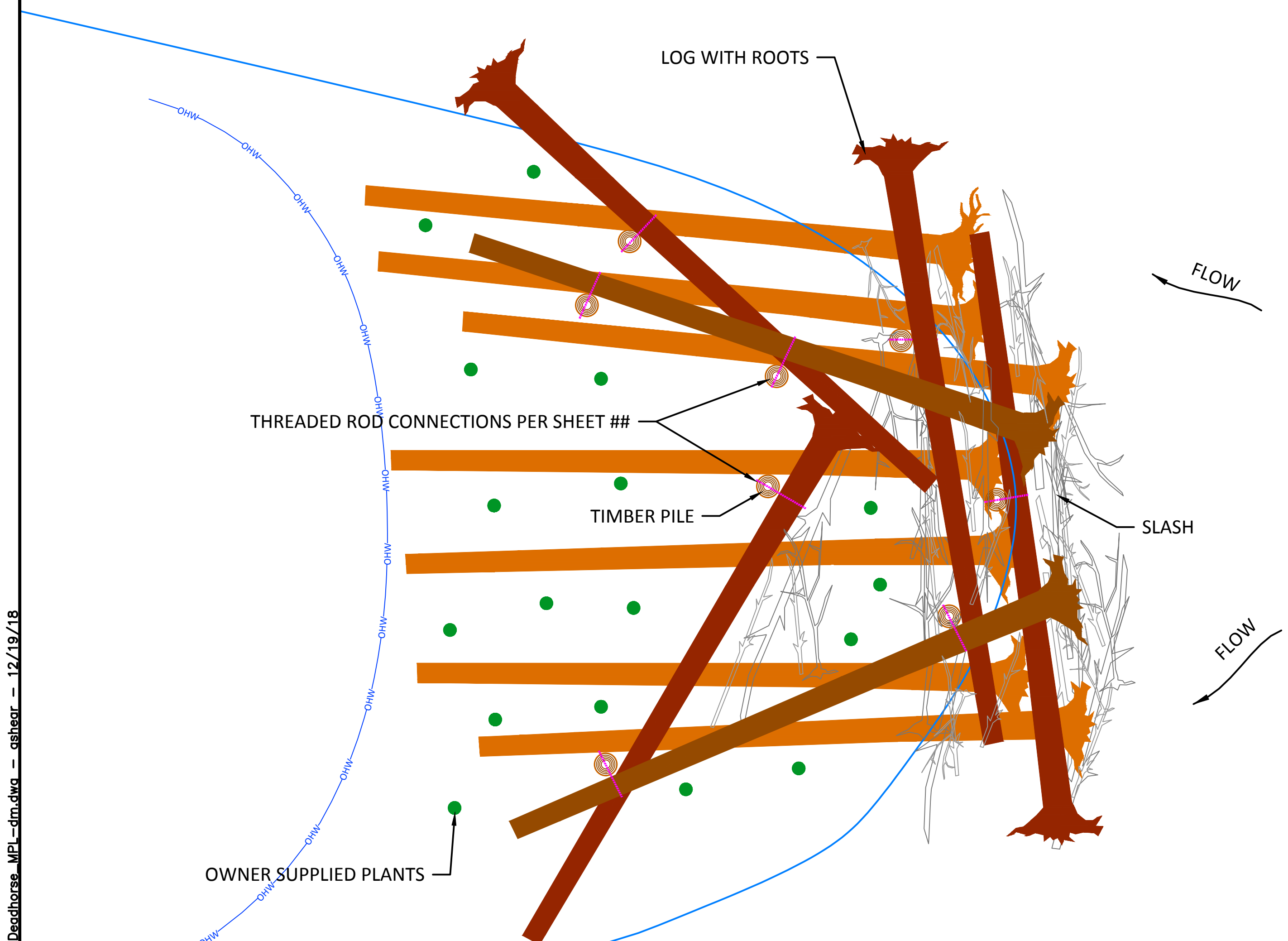
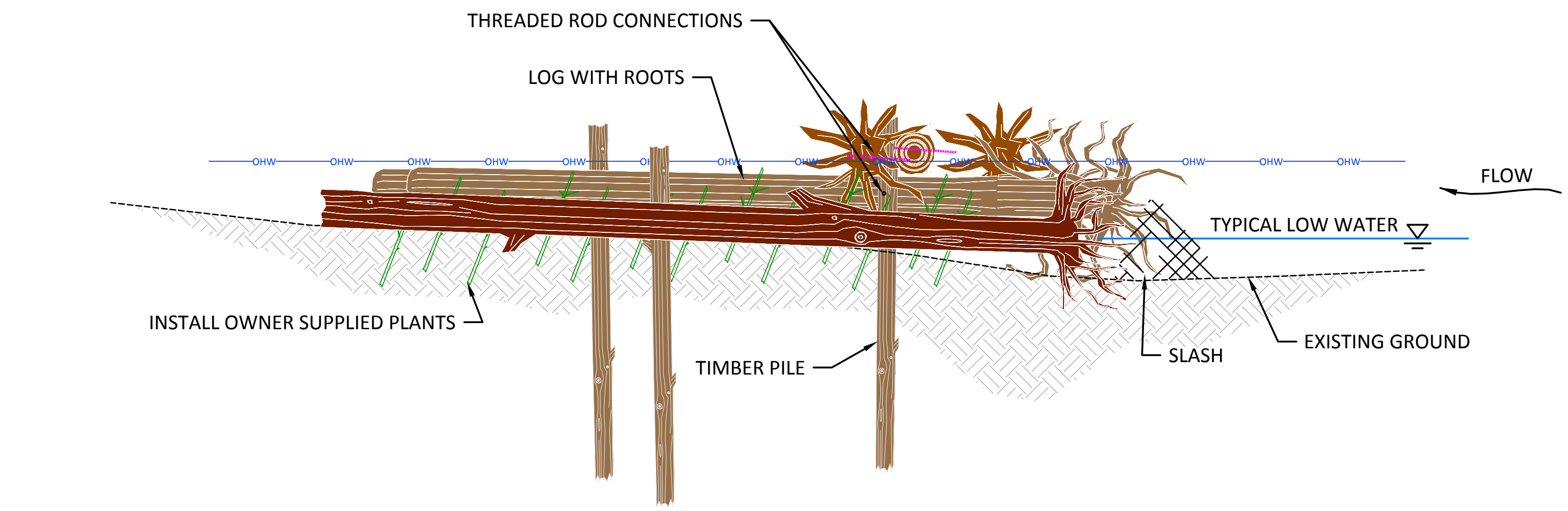
PLAN & PROFILE AREA 5

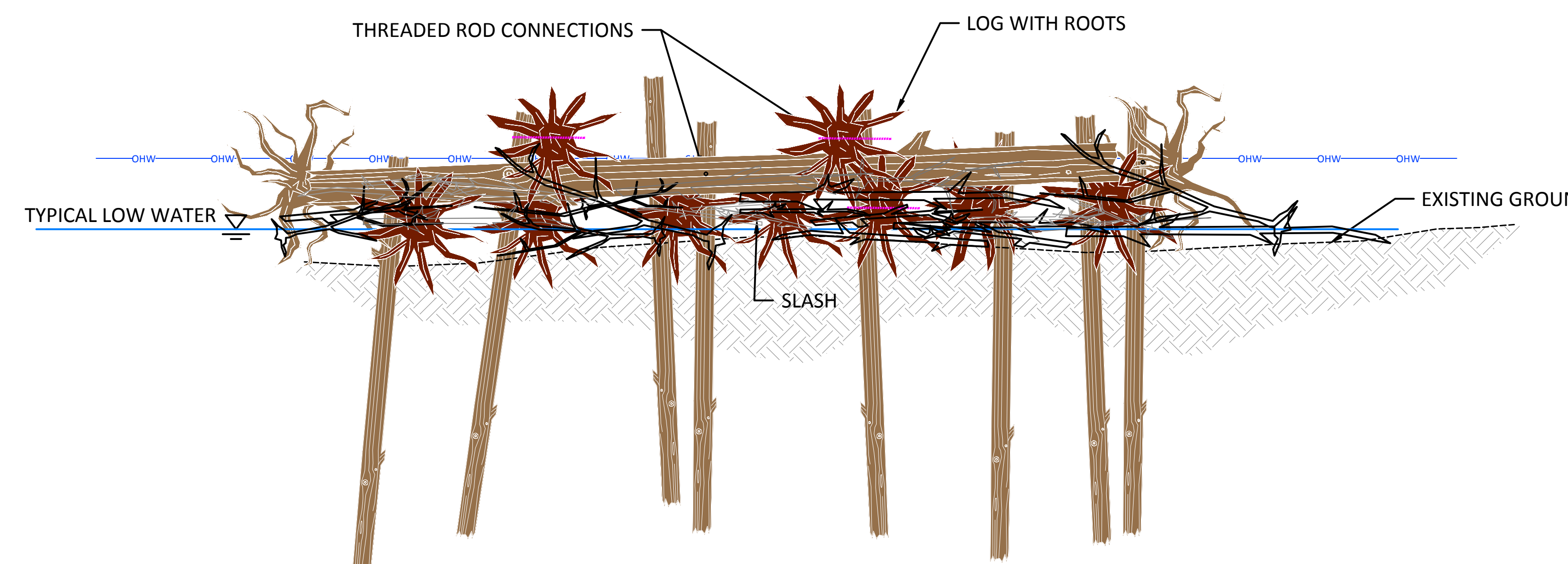
SHEET
8 OF 12



1/9 PLAN VIEW
TYPICAL BAR APEX STRUCTURE
0 20 SCALE IN FEET



2/9 SIDE ELEVATION VIEW
TYPICAL BAR APEX STRUCTURE
0 20 SCALE IN FEET



3/9 FRONT ELEVATION VIEW
TYPICAL BAR APEX STRUCTURE
0 20 SCALE IN FEET

BAR APEX STRUCTURE NOTES:

1. WOOD PLACED IN WATER SHALL BE DONE CAREFULLY TO PREVENT TURBIDITY. EQUIPMENT SHALL STAY OUT OF THE WATER EXCEPT WHERE APPROVED FOR SITE ACCESS.
2. WOOD PLACEMENTS SHOWN ON PLANS ARE APPROXIMATE AND SUBJECT TO CHANGE IN THE FIELD.
3. DEPENDING ON SITE CONDITIONS, INSTALLING OWNER SUPPLIED PLANTS MAY OCCUR BEFORE, DURING, AND/OR AFTER INSTALLING LOG STRUCTURE.
4. SALVAGE EXISTING WOOD ON THE GRAVEL BAR AND INCORPORATE IT INTO THE CONSTRUCTED STRUCTURE AS TO PROVIDE A NATURAL APPEARANCE.
5. SHRUBS REMOVED FROM SITE ACCESS SHALL BE INCORPORATED INTO THE STRUCTURE AS SLASH.
3. VARY THE APPEARANCE OF TIMBER PILES BY INSTALLING THEM AT ANGLES AND WITH DIFFERENT TOP HEIGHTS. BREAK OR ROUGHEN THE TOP OF PILES FOR A NATURAL APPEARANCE. CAMOUFLAGE PILES USING SLASH.
4. PILES SHALL BE INSTALLED BY VIBRATORY DRIVER. PILE DEPTH SHALL BE MINIMUM 14'. FINAL DEPTH TO BE DETERMINED BY PULLOUT TEST RESULTS.

NO.	BY	DATE	REVISION DESCRIPTION

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DM APPROVED	12/11/18 DATE	18-02-17 PROJECT

DEADHORSE TUNNEL PHASE 1 & 2
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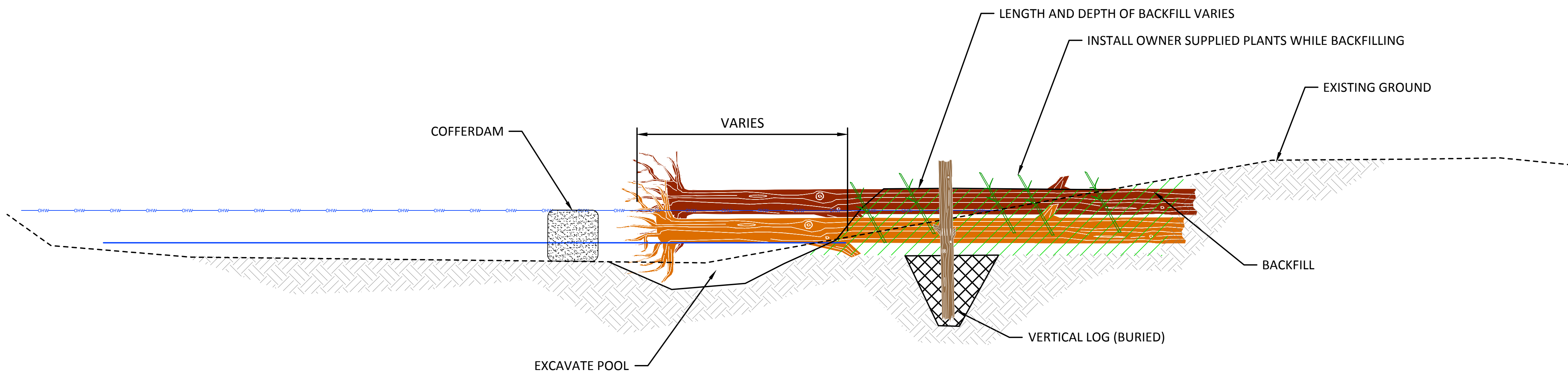
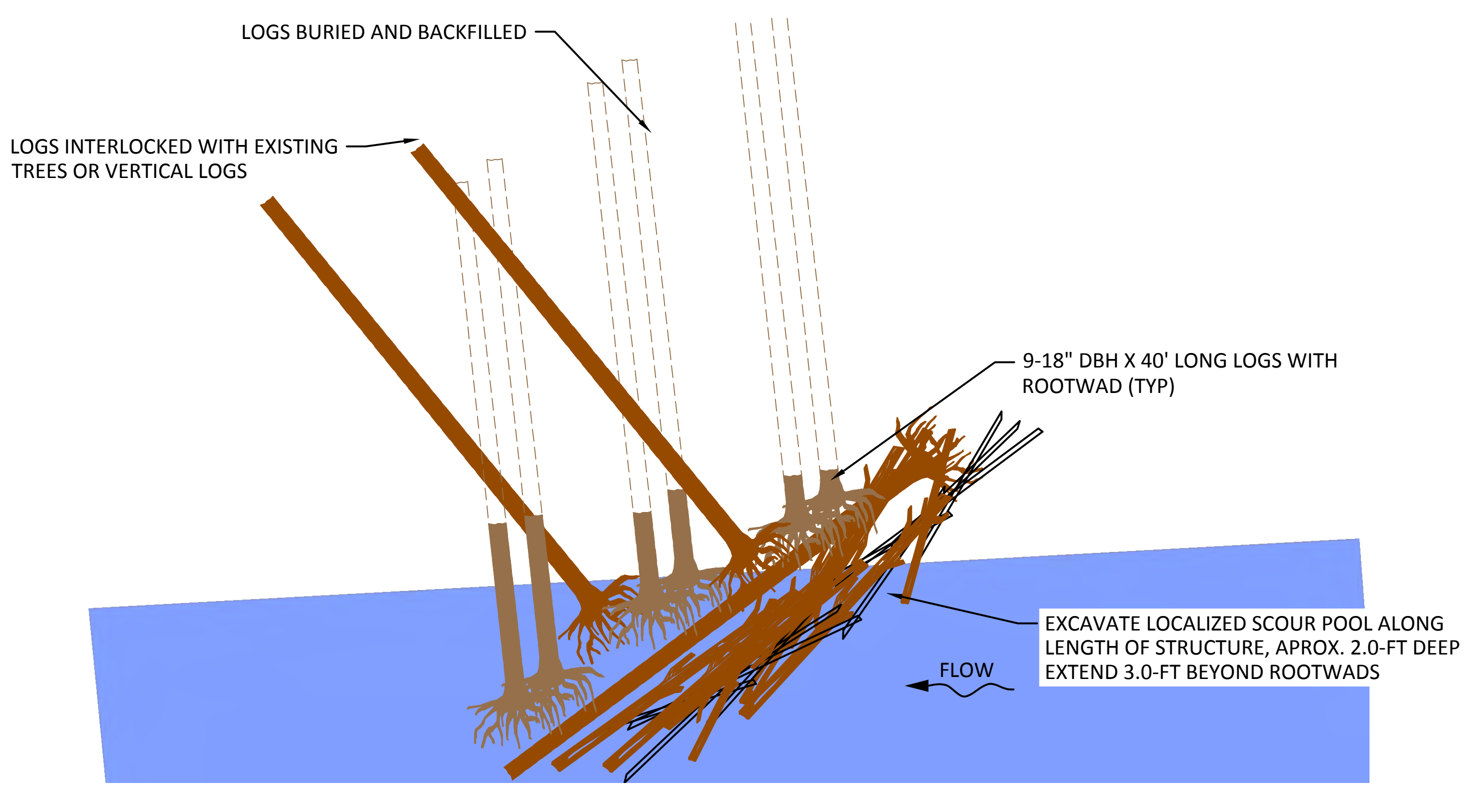
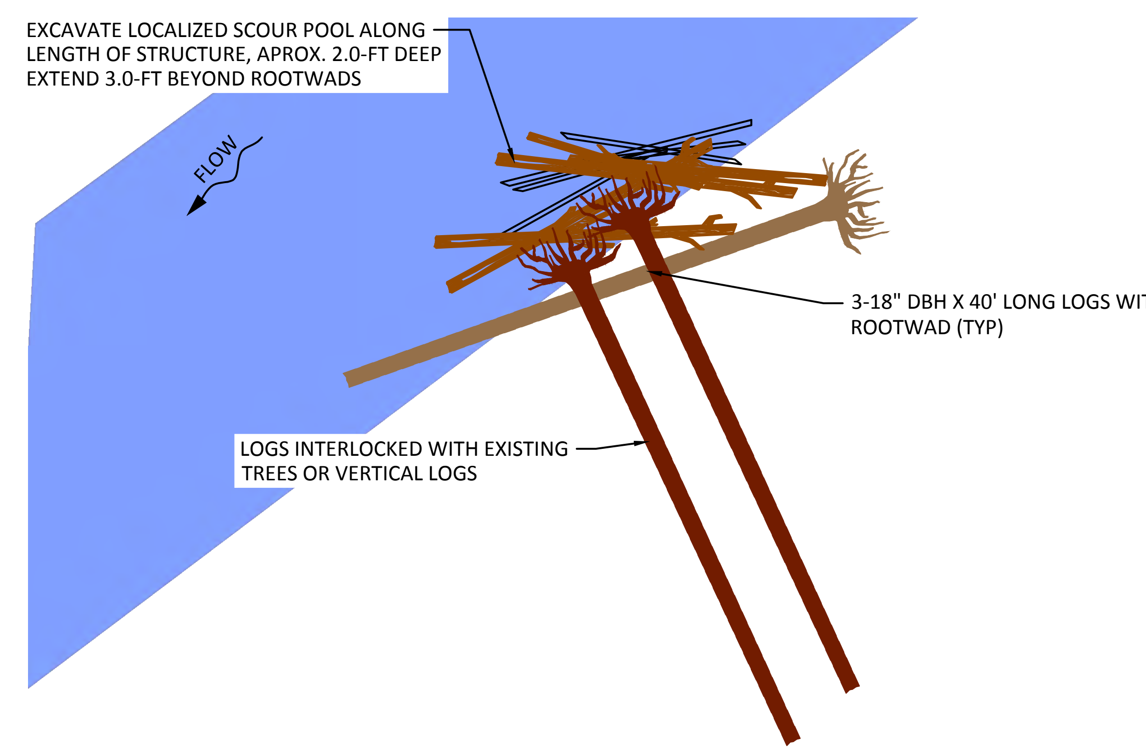
TYPICAL SECTIONS



1/10 CHANNEL MARGIN JAMS (SCALE IN FEET: 0–20)



2/10 PLAN VIEW - LARGE CHANNEL MARGIN JAMS (SCALE IN FEET: 0–30)



3/10 PLAN VIEW - SMALL CHANNEL MARGIN JAMS (SCALE IN FEET: 0–30)

NO.	BY	DATE	REVISION DESCRIPTION

GS (DRAWN)	DM (DESIGNED)	DM (CHECKED)
DM (APPROVED)	12/11/18 (DATE)	18-02-17 (PROJECT)

DEADHORSE TUNNEL PHASE 1 & 2
UPPER WENATCHEE RIVER, RIVER ROAD
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TYPICAL SECTIONS

SHEET 10 OF 12

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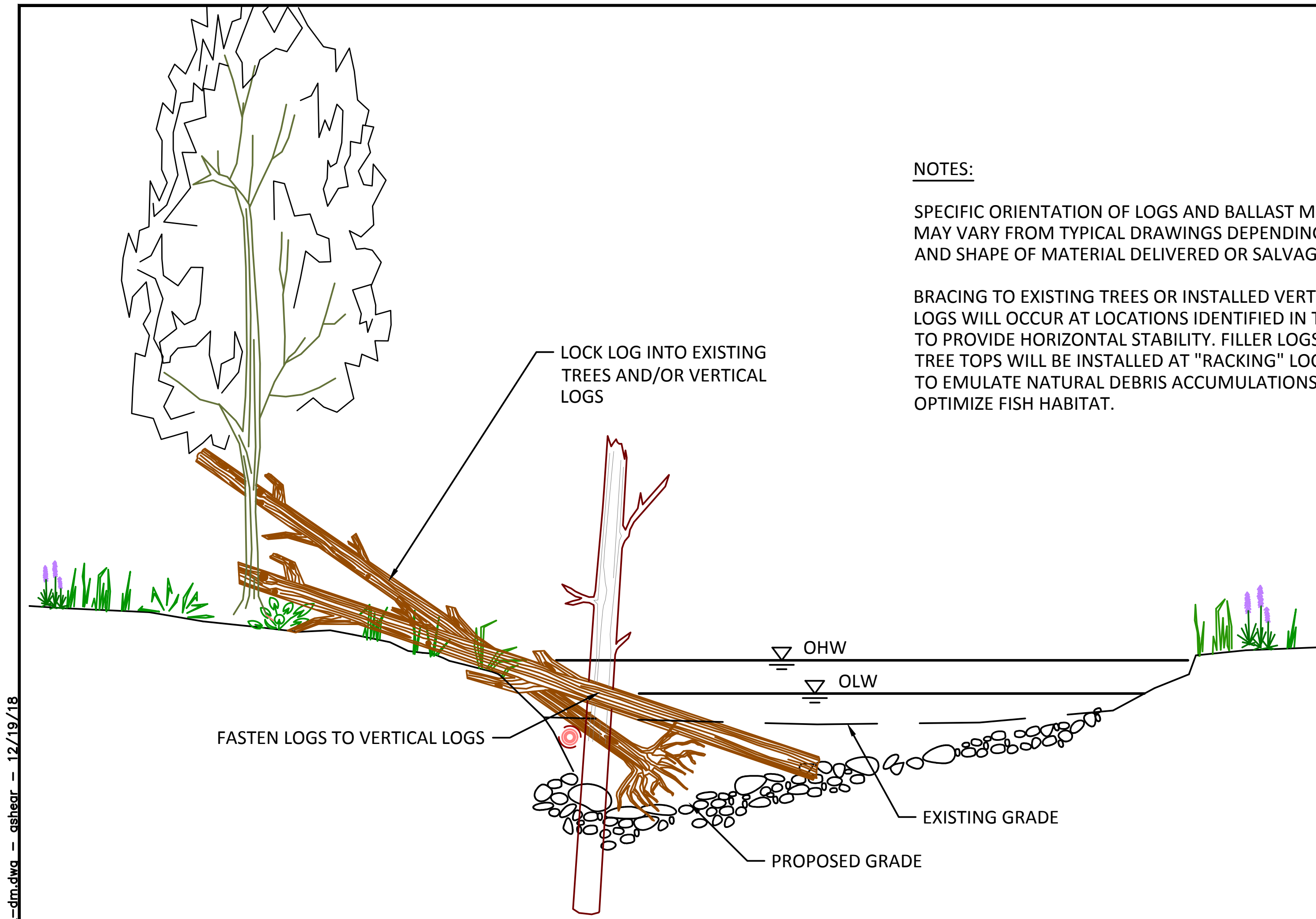
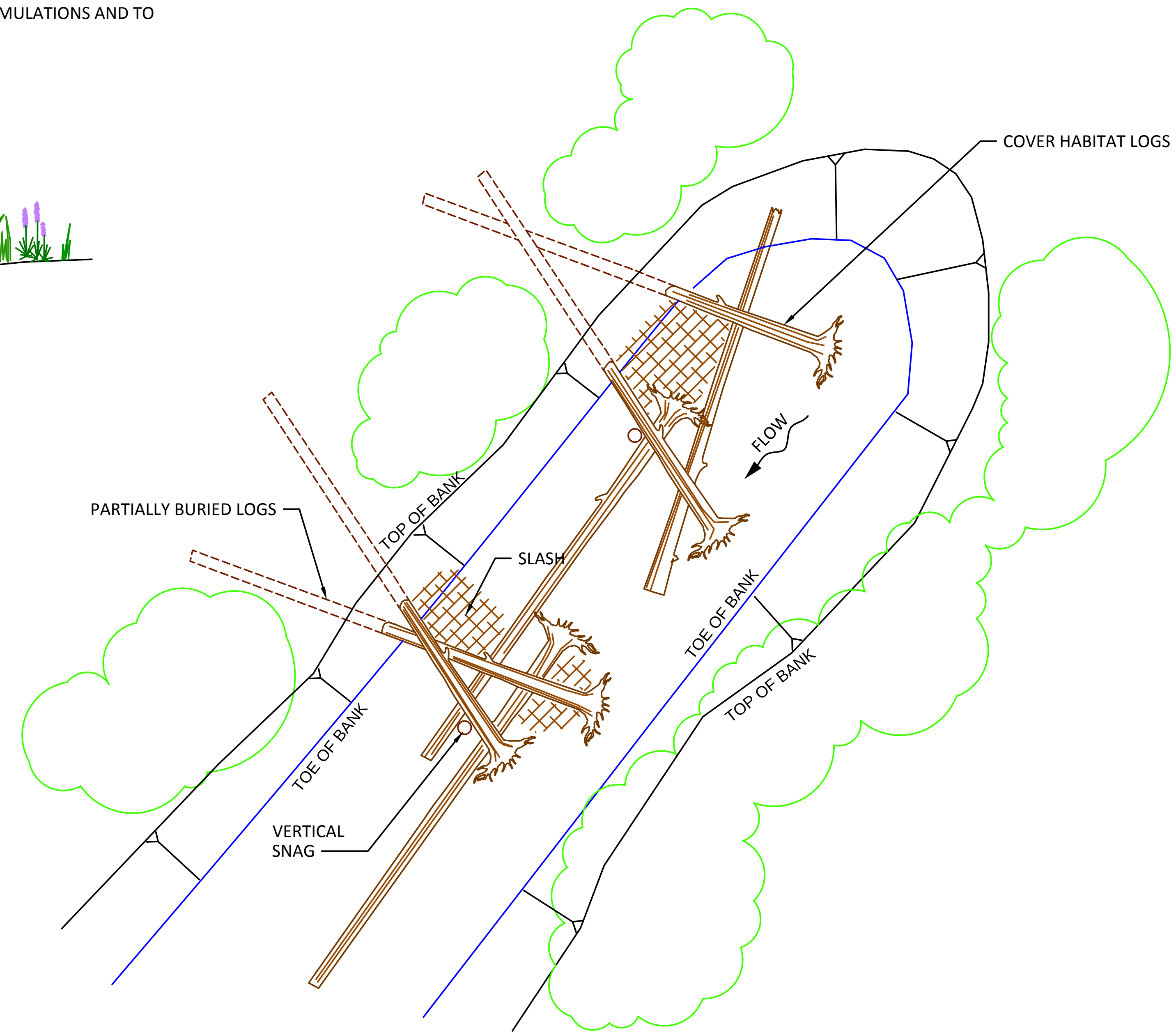


1
11
SECTION - TYPICAL BACKWATER HABITAT WOOD
NOT TO SCALE

NOTES:

SPECIFIC ORIENTATION OF LOGS AND BALLAST MATERIALS MAY VARY FROM TYPICAL DRAWINGS DEPENDING ON SIZE AND SHAPE OF MATERIAL DELIVERED OR SALVAGED.

BRACING TO EXISTING TREES OR INSTALLED VERTICAL LOGS WILL OCCUR AT LOCATIONS IDENTIFIED IN THE FIELD TO PROVIDE HORIZONTAL STABILITY. FILLER LOGS AND TREE TOPS WILL BE INSTALLED AT "RACKING" LOCATIONS TO EMULATE NATURAL DEBRIS ACCUMULATIONS AND TO OPTIMIZE FISH HABITAT.



2
11
PLAN - TYPICAL BACKWATER HABITAT WOOD
NOT TO SCALE

NO.	BY	DATE	REVISION DESCRIPTION

GS DRAWN	DM DESIGNED	DM CHECKED
DM APPROVED	12/11/18 DATE	18-02-17 PROJECT

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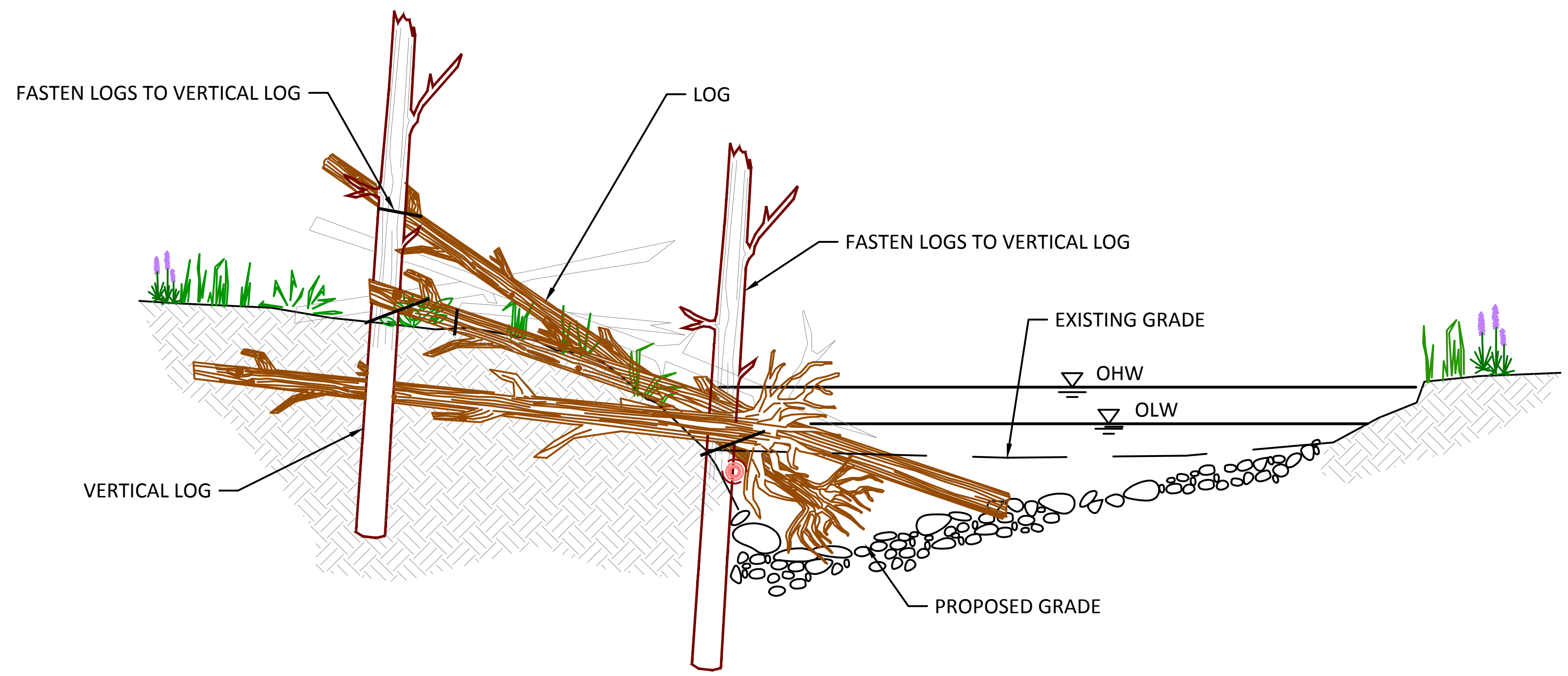
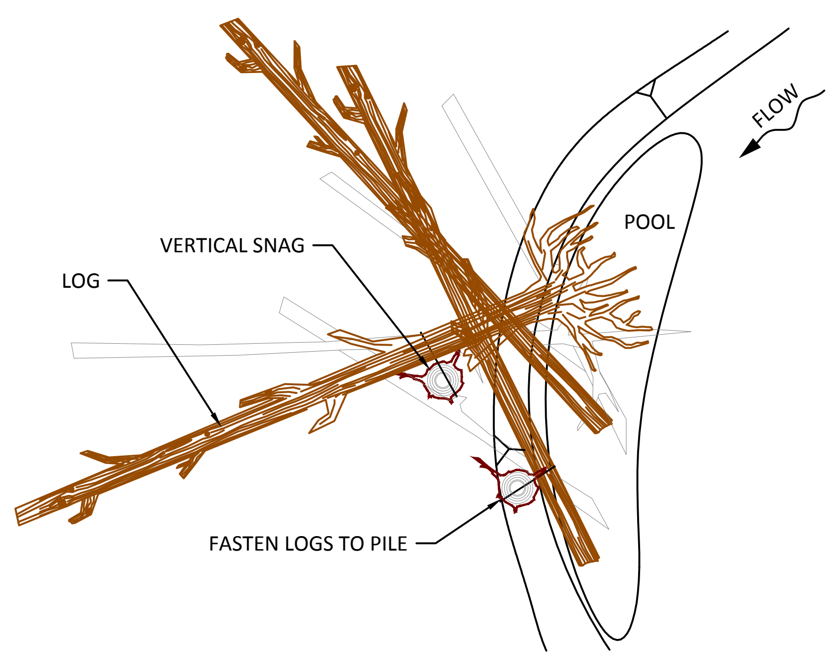
DETAILS



1/12 SECTION - TYPICAL HABITAT COVER WOOD

NOT TO SCALE



2/12 PLAN - TYPICAL HABITAT COVER WOOD

NOT TO SCALE

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DM APPROVED	12/11/18 DATE	18-02-17 PROJECT

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DETAILS

Appendix C: HEC-RAS 2D modeling results, existing conditions

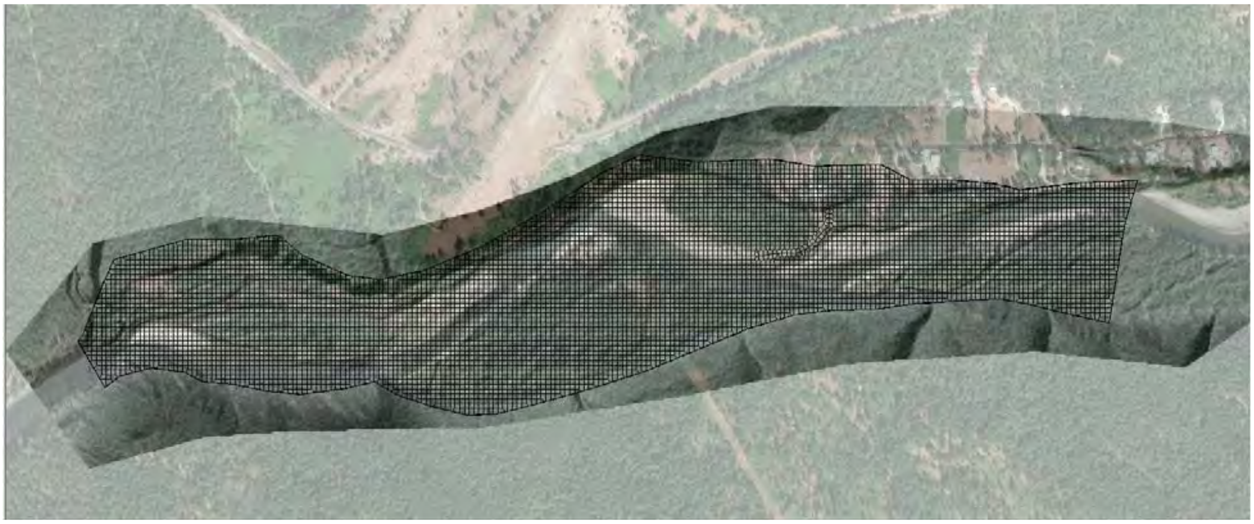

Figure 1. Deadhorse Tunnel HECRAS 2-dimensional model region

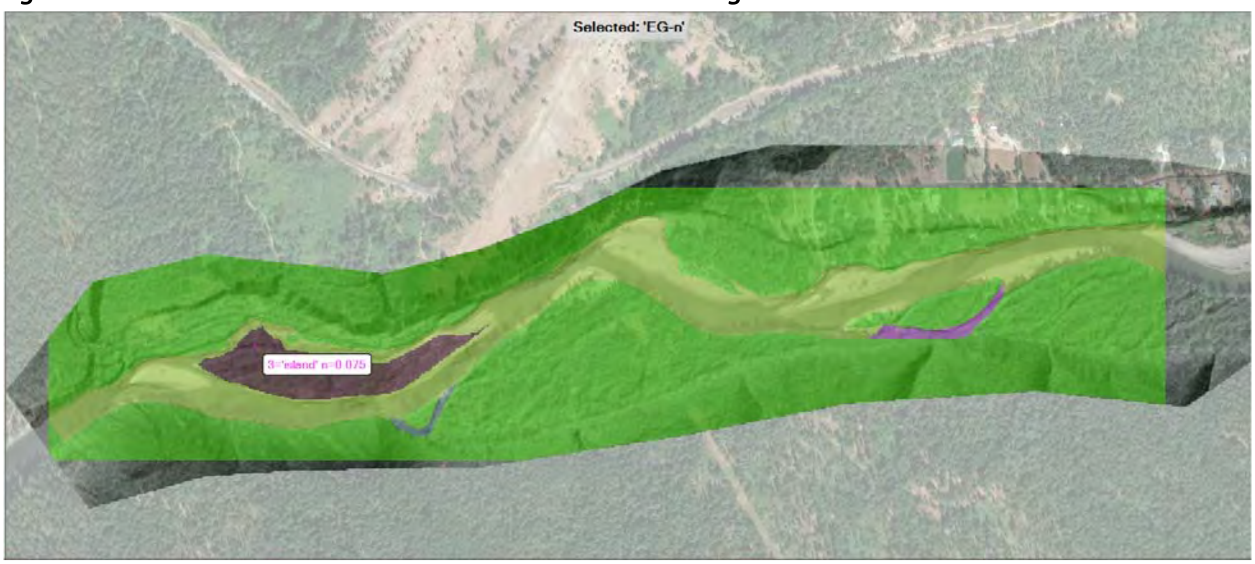

Figure 2. Mannings n regions (dark green: forest n=0.08; brown: island n= 0.075;light green: channel n = 0.038; other: side channel n = 0.038).

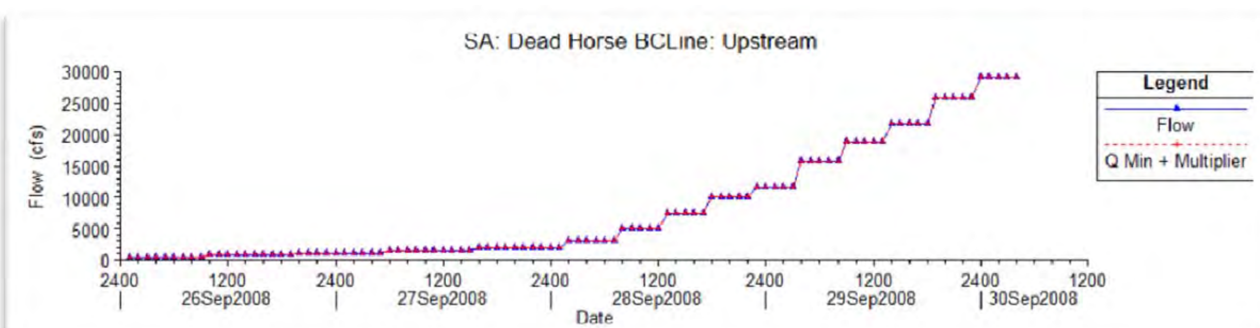

Figure 3. Hydrograph used in the hydraulic model.

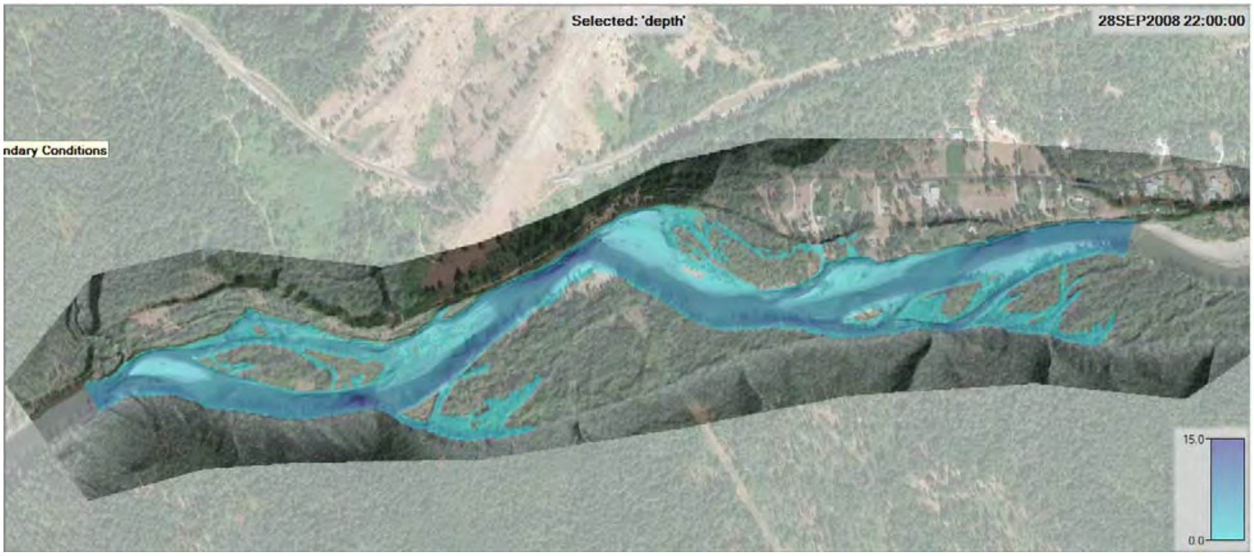

Figure 4. Modeled water depth for the 1.5-year flood event under existing conditions.

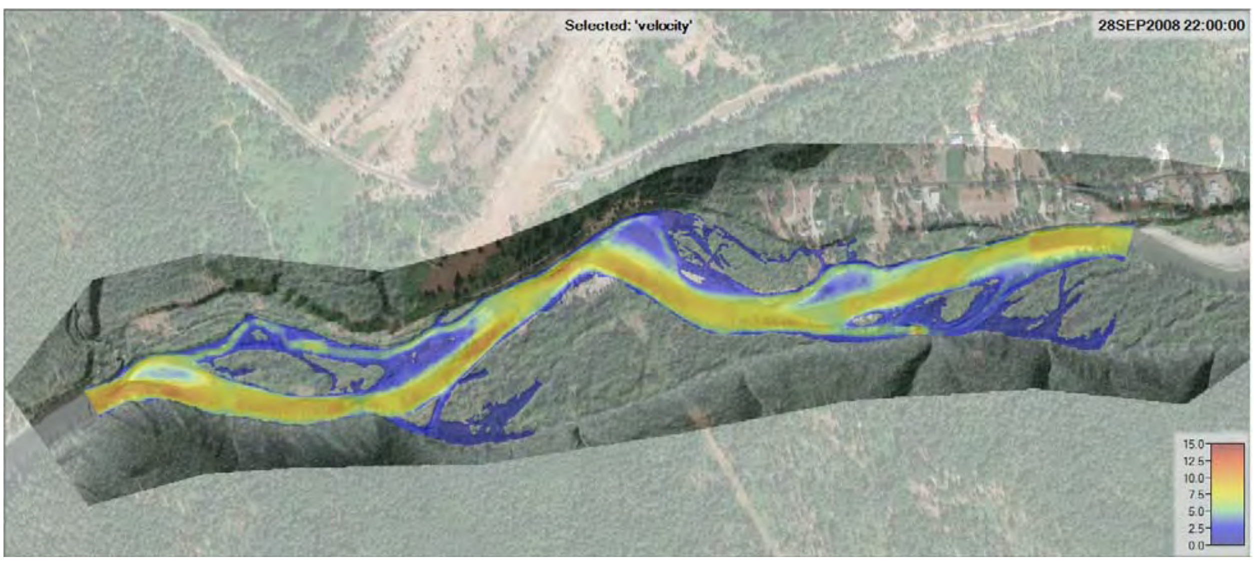

Figure 5. Modeled water velocity for the 1.5-year flood event under existing conditions.

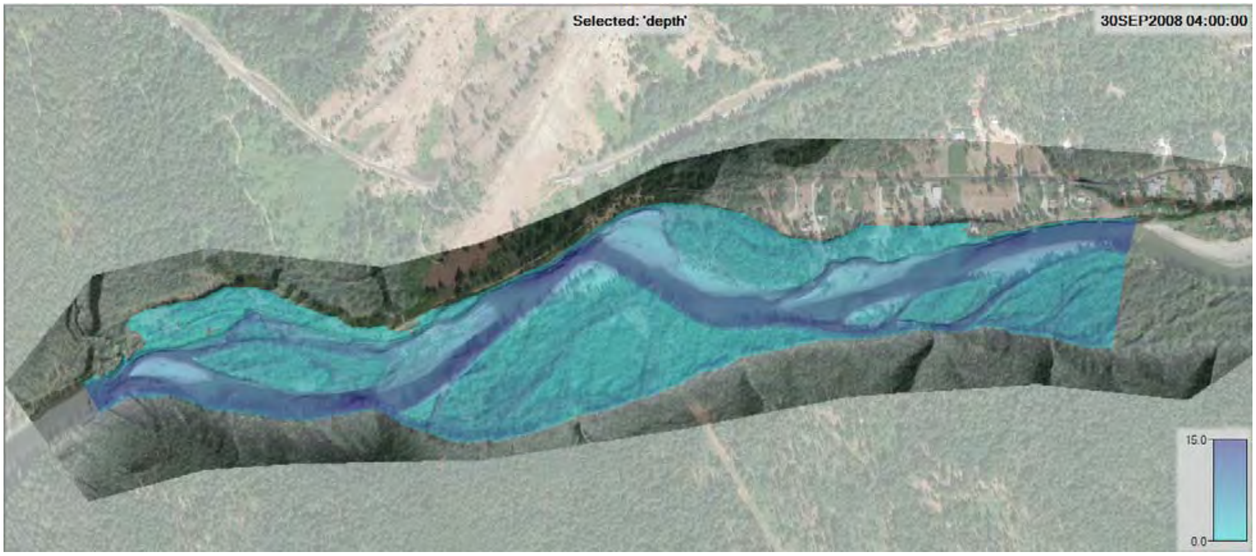

Figure 6. Modeled water depth for the 100-year flood event under existing conditions.

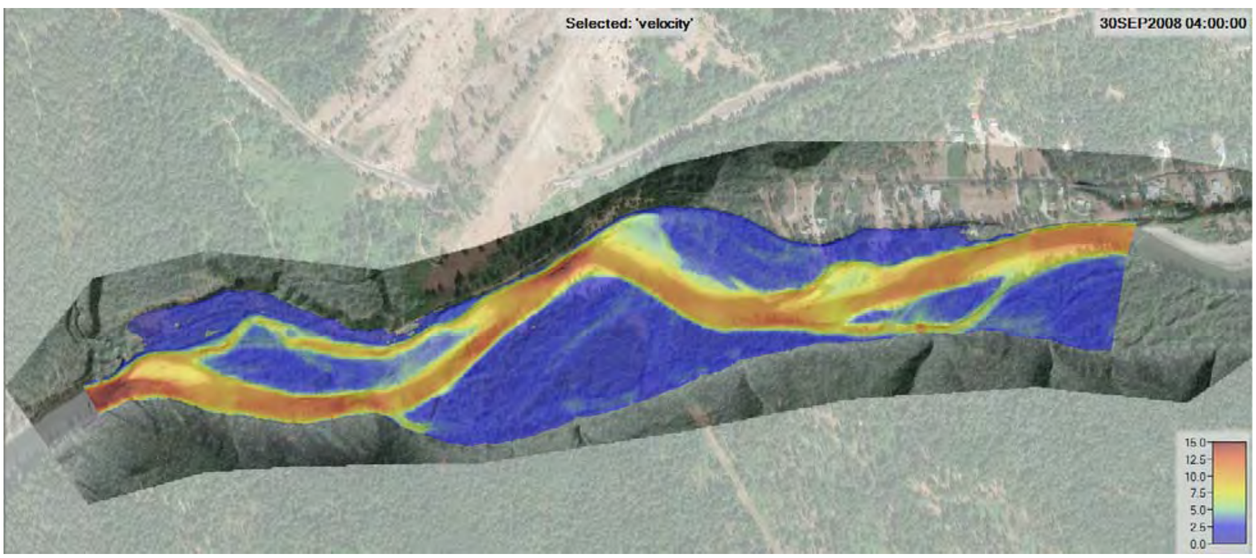

Figure 7. Modeled water velocity for the 100-year flood event under existing conditions.